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Contents

The Place of the Engineer in Industrial Management
A Large Company's Viewpoint — *R. G. Ernest* 203
A Small Company's Viewpoint — *F. W. Miller* 205
The engineer is playing an increasingly important role in the field of industrial management, in both large and small organizations

1956 Lightning Field Investigation on the OVEC 345-Kv System
R. H. Schlomann, I. B. Johnson, W. S. Price, J. G. Anderson
A re-evaluation of present procedures for estimating lightning flashovers on transmission lines 208

John K. Hodnette 1957 Edison Medalist
Medal History — *E. B. Robertson* 214
The Medalist — *W. H. Sammis* 214
Acceptance — *J. K. Hodnette* 216

Treeing Effects in Polyethylene — *D. W. Kitchin, O. S. Pratt*
Results are given of studies made of "trees," a characteristic form of latent dielectric breakdown damage 218

Performance of UHF and VHF Television Transmitting and Receiving Equipment
W. J. Morlock, W. O. Swinyard
General problems and specific studies undertaken by TASO Panels 1 and 2 to obtain data on uhf and vhf for the FCC allocations study 226

Data Transmission Testing Set — *J. E. Boughtwood, T. A. Christie*
An electronic, transistorized testing set has been designed for laboratory use in the development of binary data transmission systems 232

Large Gas Turbines for Central Station Application — *Z. S. Stys*
Background history for application of the gas turbine to the utility field and the experience gained with such units 238

The Financial Return on Railway Electrification — *H. F. Brown, H. E. Marmaros*
A straightforward method is described for computing costs of railway electrification relative to diesel-electric operation 244

THE COVER: Technician at the Hughes El Segundo, Calif., plant plugs in "flip-flop" subassembly for rigorous production test during manufacture of "Digitair," first airborne digital computer to go into actual production. Story appears on page 272.

CONTENTS CONTINUED

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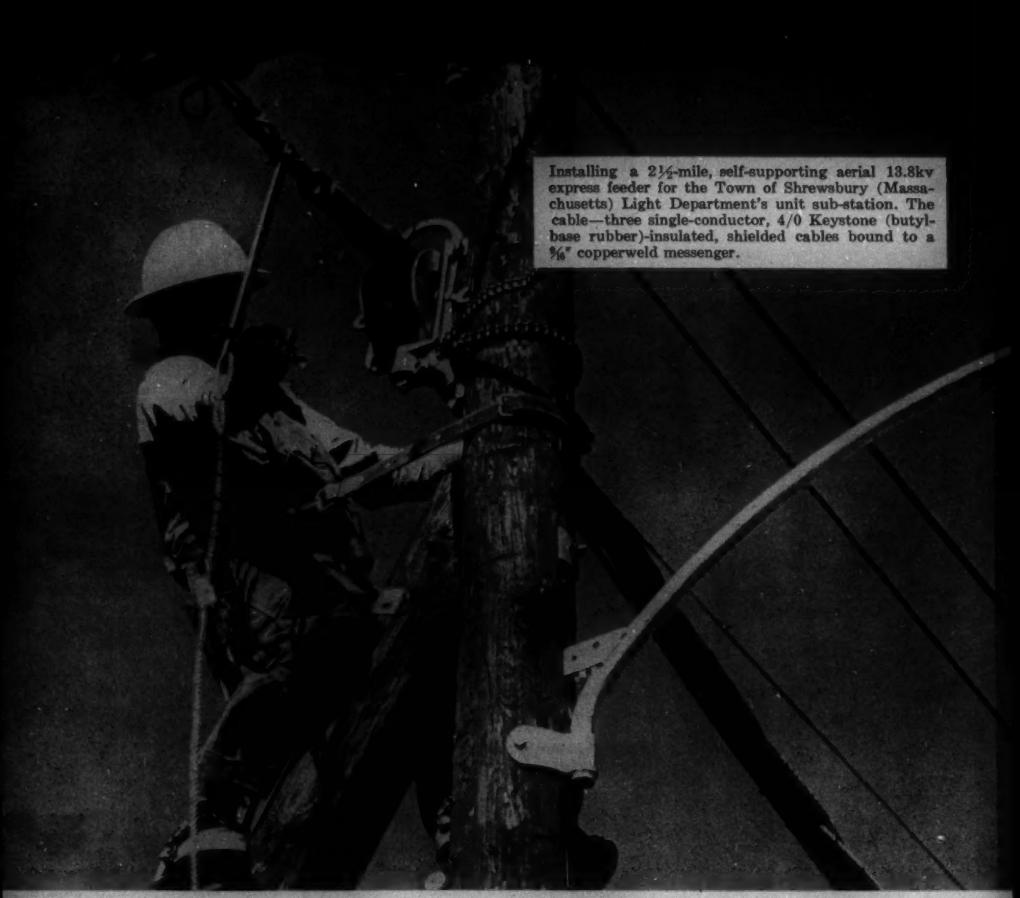

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Contents Continued

Technical Paper Digests

Component Minimization in Electronic Switching	*T. J. Beatson*	213
Cable Installations on Bridges	*E. W. Scheirer, Leon Winitsky*	224
Impedance and Return Loss Performance	*L. B. Bogan*	225
Corona-Level Scanning of High-Voltage Power Cables	*F. H. Gooding, H. B. Slade*	236
Nation-Wide Switching of Intertoll Trunks	*O. F. Wallman*	237
Selection and Use of Servo Performance Criteria	*W. C. Schultz, V. C. Rideout*	247

Departments

Electrical Engineering Education	248
AIEE in Clemson College	248
Technical Manpower Issues and Related Educational Problems	248
NSPE Nation-Wide Scholarship Program	249
An Electrical Engineer in Industry	251
FIER Awards Grant to New Stanford Research Laboratory	252
Institute Activities	255
Tulsa, Oil Capital of the World, Will Be Host to South West District Meeting	255
Tentative Technical Program for Nuclear Engineering and Science Conference	258
AIEE Future Meetings	261
20th Anniversary Meeting of the American Power Conference	262
District No. 2 Meeting Will Cover "Engineering in the Nation's Capital"	264
AIEE–ASME Sponsor Management Conference	265
Pulp and Paper Industry Subcommittee Plans Conference	266
Conference Papers Open for Discussion	267
Committee Activities	269
AIEE Personalities	269
Obituaries	270
Membership	271
Of Current Interest	272
Major Scientific H-Bomb Defense Advance	272
Efficiency Noted in Heat-to-Electricity Converter	273
Silicone Insulated Motor Exposed to Radiation Source	274
Clocks, Sputniks, and Primary Standards	275
Future Meetings of Other Societies	275
International Inventors' Exhibition	276
Automation Featured in Motor and Generator Manufacture	277
Ultrasonic Welding of Various Types of Materials	279
Letters to the Editor	279
New Books	280
Technical Literature	281
Industrial Notes	18A
New Products	22A
Trade Literature	44A
Index to Advertisers	62A

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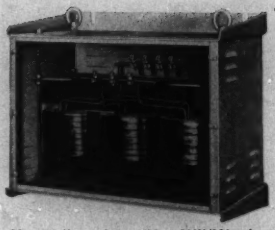

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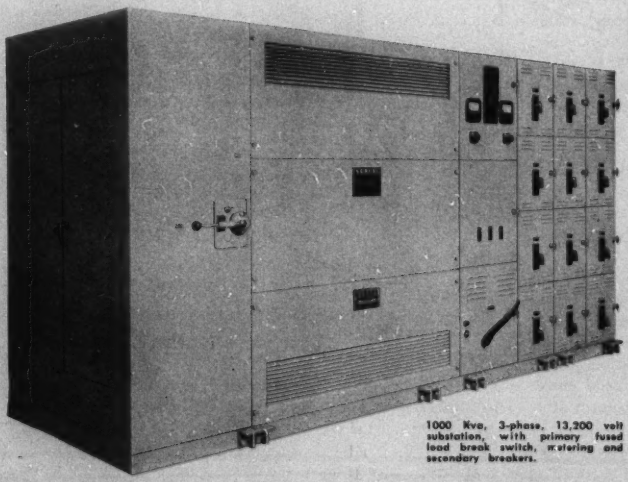

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The Place of the Engineer in Industrial Management

Management, in recent years, has become more and more concerned with projects requiring the use of engineering judgment. Thus, the engineer is playing an increasingly important role in the field of industrial management. The experiences of two typical firms—one large and one small—are described.

A Large Company's Viewpoint

R. G. ERNEST

IN RECENT YEARS, the job of managing a large industrial organization has become an increasingly complex and taxing assignment. Technological advances have called for a broad variety of specialized skills. The growth of the labor movement and the increasing responsibilities of management to Government, to employees, and to the public, have placed many relatively new burdens on the business executive.

All of these factors make more and more evident the need for planned development of a strong management team. They call for an even higher quality of leadership ability in a company's management ranks. There is scarcely an industrial business today which is supplied adequately with high-caliber management material.

Thus, when analyzing the place of the engineer in industrial management, we should recognize that we are viewing a man who has contributed in some measure to the technological advances of which we speak and who, in his earlier years, has acquired a rather specialized skill—namely, the ability to think, to analyze, and to solve problems in his particular engineering discipline. In the first years, with most industrial organizations, the engineer is applying his skills to develop new ways of making things or to improve the methods currently employed in his company to carry out its function. It could be said that in doing this he is already a part of the management team, because he contributes substantially to the company's success or failure in its meeting competition and its ability to maintain or acquire a sound financial position. In this function, he is really a contributor to the company's operation, not necessarily a manager.

Most companies recognize that not all engineers are equipped to be managers. Some do not really want to devote their efforts to managing; they prefer the role of a contributor and derive deep satisfaction from it. Others shy from managing because of the complex problems involved in dealing with individuals, unions, and the public at large. They feel insecure in this climate, sometimes because of their fundamental desire and training to deal with material things rather than human beings and organizations. In Esso Standard, the need for both types of engineer—the contributor and the manager—is well recognized. Avenues of advancement are kept open for development along either line. Inasmuch as we are here concerned with the operating and industrial management side of the business, wherein there is a greater need for the manager-type engineer, we can set aside the role of contributor and look into the development of engineers for the management field. Here will be described this company's approach to assisting engineers to progress into management positions—the approach to management development.

Probably the most important ingredients in this program for such development are the "management climate" in which a man works and an understanding of the basic management principles so essential to a successful organization.

Basically, the management climate involves a recognition that human assets are far more important than raw material reserves, new equipment, or financial strength. Such a management philosophy is not born overnight. There must be a deep-rooted conviction and understanding that people, not things, spell success for an organization. An industrial organization is known and is run by the people in it, not by its various plants or financial statements. This climate also centers about the belief that top management must concern itself in the realms of policy making and, most importantly, planning and organizing to get results through others. Top management alone is not able to perform all the detailed managerial tasks. Results must be attained through motivating and organizing other people. Our management philosophy takes into account the fact that the development of managers is to a very large extent a natural by-product of a well-managed business that is "people centered." This, then, is the climate felt necessary for the development of future managers.

The basic management principles are the keys to understanding the characteristics that one must have to be a successful manager. These basic principles are well

Essentially full text of two papers presented at a panel discussion at the 25th Annual Meeting of Engineers' Council for Professional Development, held in conjunction with the Fourth General Assembly of Engineers Joint Council, New York, N. Y., Oct. 24-25, 1957.

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known and often repeated; they are not new or original with the author or with the company.

However, it is our conviction that men develop by learning the principles of good management and practicing them in positions of increasing responsibility.

Some of these basic principles are:

1. *Delegation.* Placing responsibility for a job upon the individual and holding him accountable for results. Delegation is probably the keynote of good management development. It encourages men to grow and reach out.

2. *Assuming Responsibility.* Management must assume responsibility for its success or failure. Thus, the individual is helped to understand that he is responsible in the final analysis for his own success or failure.

3. *Facing Up to Problems.* Management should provide leadership by a willingness to meet difficult personnel and plant problems and solve them promptly. This is good for the business and it provides the right environment for individuals to work and grow in.

4. *Challenging Jobs.* Good men learn fast. They grow and develop as they are challenged by work assignments that tax their capacity. Shaping the job experience of individuals is a most important part of management development.

5. *High Standards of Performance.* Management should demand good performance. Performance on the present job is the best indicator of performance on a job of greater responsibility.

6. *Encourage Personal Initiative.* There is no better incentive to individual self-improvement than to work for a management that is striving for improvement and is receptive to new ideas.

The program for application of these principles in the climate just referred to necessarily involves the selection of individuals for participation. Most progressive companies, like good athletic teams, are characterized by insistence upon plenty of good starting material. Thus, the process of selection of engineers really starts at the colleges and universities with the recruitment of new men into the organization. This selection is done by line management participation in campus recruitment in a large number of schools. The men most qualified for selection, on whom will rest the responsibility for development, make the final choice. The methods used are not unusual; they include a mechanism to insure that more than one person is involved in the selection and that combined judgment is used in the final choice. The selection consists of an analysis of the individual qualifications and characteristics to determine those men with the highest degree of ability so that when given the environment, opportunity, and encouragement, the candidate will have a desire and willingness to develop himself.

The development process for those men within the company is based on the premise that the selection of men for further growth should not be limited, but rather open to all who have the necessary potentialities. The aim is to develop each individual to the maximum of his capabilities.

The first step in the detailed functioning of the process is taking inventory. This involves a constant review of the organizational structure; the need for change; the identification of key positions; the make-up and requirements of key jobs; the definition of qualified replacements for such jobs; the determination as to whether the replacements are ready now or need further experience and development; and many other determinations. This inventory review is one important phase of the "uncovering" process. Such reviews force management to look sharply at their young men who are beginning to demonstrate ability and potential.

The second step is the evaluation of people. A man's ability and his potential for further advancement are judged primarily on his job performance. Here again we use the combined judgment of qualified people who know the man best. His progress is followed very closely from one job to another. If he continues to demonstrate ability, his job experience is broadened through a planned short- and long-range program, consistent with the needs of the business. The endeavor here is not only to broaden the man's work background, but also to test how he fits in various work situations, and how he measures up under new supervision.

The third step is the provision for broadened job training. It is recognized that men need opportunities to take on responsibility and make decisions. Basically, men learn to manage through managing. Our most important technique to provide for this experience is that of rotational job assignment. It probably is our best management development technique. For the engineer, this may involve an assignment as the supervisor of an operating unit in a refinery; then a job supervising a group or groups of staff engineers; then a responsibility as a general supervisor of a section of a plant involving many operating units; and so on. These assignments usually provide training and experience in actual job performance and, most important, provide proving grounds for greater responsibility. Such rotation may be lateral, up, and back down, or sometimes down and back up. The men who are rotated are not considered trainees. They are expected to, and do, carry the full authority and responsibility of their new assignment. These rotational assignments for development have many advantages:

1. They put the man in direct contact with responsibilities he would not otherwise encounter if developed strictly along one line of endeavor. For example, an operating assignment for the engineer necessarily involves him with the responsibility for wage earners and some form of union contract.

2. They place the man in positions of responsibility for people. This involves training, evaluating, and developing people themselves.

3. They help find the best man, because identification with a particular department or type of work disappears.

4. They provide for a better judgment basis. People can be judged on their over-all managing ability rather

than on special skills or experience. More people get first-hand knowledge of a man's performance.

5. They strengthen an organization as well as individuals because they break down departmental lines in larger organizations, thus encouraging co-operation, teamwork, and fresh viewpoint.

There are still other techniques for broader development; the list of methods used in helping people develop could be almost limitless. However, in our view, most of them involve development at the work place and in the work situation. Here are some ways we use those techniques: A man could be assigned to conduct training; to act as a leader of a meeting or a series of conferences; to work with a task force on a particular problem involving several departments; to committee work in the plant, such as the one on salary administration, the one on cost reduction, or that dealing with local management development. He could also be assigned to participate in collective bargaining for the local unit.

There are many other approaches to helping an individual broaden his thinking and outlook which take place off the job. Some of these in use within Esso Standard are

1. Participation in special company courses aimed to provide for sharpening of special skills or to provide a broad look at the company's operations.
2. Participation in advanced management courses conducted at colleges or universities.
3. Assignment to head up community fund-raising drives.
4. Encouragement to participate in civic affairs.
5. Encouragement to participate in technical and professional organizations.

This, then, is one approach to the development of engineers for industrial management. It is one based upon a knowledge of management principles that in themselves define the characteristics of individuals that are necessary if they are to become good managers. It is one based on the proposition that a man's development is an individual thing. His development is self-development. In addition to possessing the inherent abilities necessary to a manager, he must have the desire and the drive to improve himself. However, the company must provide the climate in which this self-development is encouraged and assisted.

It also involves the idea that men must be given the opportunity to assume responsibility, to broaden their outlook, and to stretch their ability. But, most important, it subscribes to the idea that management development must be treated as an integral part of better managing. It is a function of line management that cannot be delegated or left to chance.

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A Small Company's Viewpoint

F. W. MILLER

A PARTNER in a management consulting firm suggests that the embryo of a new industrial company is composed of a good salesman who has become dissatisfied with the scope of his activity and an able foreman whom he selects as superintendent. These two men start a new company. This is basically a sound beginning, provided that there is a product, process, or service available which can be marketed at a profit. As growth follows hard work and imaginative policies, it becomes impossible for the original owner to satisfy the demands for his time adequately. Key men are assigned progressively in management positions as the company grows.

But are engineers fully qualified to fill these management positions? Ten small industrial companies were invited to relate their experience to assist in answering this question. The replies, when summarized, give an answer overwhelmingly in the affirmative. Inasmuch as these are so directly concerned with the purpose of this presentation, let us refer to these companies' spokesmen as they tell of engineers in management positions. Their letters are valuable contributions to our interest. The following excerpts are typical:

"All of our key men in management have engineering as a background with the obvious exceptions of our financial and personnel department people."

"In the seven key positions of our works, four of them are held by men with either engineering degrees or engineering training."

"Some of these engineers have 'graduated' into management at the present time, and we find that our 'top brass' includes our vice-president and sales manager, our two assistant sales managers and our two branch office managers."

"When administrative ability is coupled with sales experience and product-application knowledge we have some of the qualities needed for top managerial positions."

"It is particularly true in a small business where managers have to get down into detail to a greater extent than in a larger business where specialists can be available, and there is no question that his operating decisions are sounder if he understands the technical aspects of that with which he is dealing."

"Approximately 70% of our district sales managers and our salesmen are engineers."

The percentage of engineers in executive and managerial positions in these 10 industrial companies varies from 60% to 80%. This is a most impressive number of engineers used in management positions. But, in a sub-

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jective sense, have engineers been drafted to management positions only because they can contribute to solution of engineering problems? Are they without an adequate knowledge to solve the many problems other than engineering which are part of a successful manager's normal business life?

In recent years, management decisions have been concerned more and more with projects involving engineering judgment; and in these the engineer became an essential adviser to management. This kind of work expanded as the technological horizon lengthened. This trend has accelerated at a rapid pace. Concurrently, the use of engineers has become so great that, seemingly, there is not a sufficient number to satisfy the very real need for them. One of the reasons for the claimed scarcity of engineers can be that they have found many more openings in management positions in industrial companies.

This greater use of engineers is a welcome corollary to the laymen's belief that engineers are limited to the jobs naturally assigned by the normal definition of the word "engineer." It is important to recognize that engineers who have undeveloped talents are lost to the profession when these abilities propel the individual to use his full potential. The acceptance of the engineer–manager in business will retain many who might otherwise be lost to other professions. Such loss would deplete the ranks of managers to business' detriment.

An ever-increasing standard of living has become a cliché, and our dependence upon the engineer for it is considered quite wholesome. But the economy rises to a higher level on a broad front, with the scientific advance limited to pointing the way.

The engineer generally has not been prepared for management positions in his formal educational training. The college curriculum has been devoted, and to a large extent is still devoted, to the basic sciences and the application of them to man's welfare. Urging on the part of industrial leaders has aroused an interest on the part of educators to broaden the curriculum base to include subjects essential to management functions.

But the question of adequacy keeps recurring, i.e., is the engineer sufficiently well-rounded in his knowledge of all the company operations?

It is necessary for the engineer interested in fitting himself for management work to study and gain experience in management skills. The engineer must have a will and a desire to devote a portion of his time preparing himself for management work. This mental condition is a necessary prerequisite for the studying required. The mental soil must be prepared for planting of additional seed. An engineer is not automatically a manager or an executive. There are many hours required in the additional training.

What must an engineer add to his knowledge and experience to become a manager in an industrial organization? These are some of the additional areas in which he must become informed:

Corporation finance
Motivation of the individual
Delegation of responsibility and authority
Decision-making
Setting an example or leading
Improving own capacity
Formulating and achieving the company's over-all objectives
Co-ordinating functions and people
Exercising business judgment

In progressing from an engineering position to a management position, the individual has time to acquire this training. Training needed is composed of formal study and experience. The formal study can be obtained in several ways, such as at college evening classes; at seminars, as given by management associations; or in training programs, at colleges, which run from a few days to a few weeks in duration. Experience can be acquired through day-to-day assignments in business life; through committee work in civic organizations; and through officer and committee work in engineering societies, trade associations, etc.

As proficiency in these becomes evident, more responsibility and more authority will be placed within the normal scope of the individual's position. The rate at which the engineer is given these additional assignments is dependent upon his ability to use these new tools which he is learning.

Fortunately, the engineer who is creative and has a receptive mind will be singled out rather early through evidence of his desire to grow into more responsible management positions. Such a mental attitude finds assistance in courses such as the following:

Effective speaking and writing
Accounting
Human engineering
Contract law or logic
Insurance and taxes
Industrial relations
Public relations
Sales methods and incentives
Advertising

The employment of engineers in our company, for example, is largely through three channels:

1. Before graduation, as a co-operative student
2. At the time of graduation
3. A few years after graduation

In the first two cases, those employed are placed in a 6-month training course during which they are assigned to the following departments:

Engineering
Research
Time study
Production
Inspection and quality control
Manufacturing
Sales
Cost

The time in each department depends on the individual's interest, but is sufficiently long to gain a general understanding of the work in the department and its relation and importance to other departments. Monthly during this training period, the men are given an opportunity to discuss problems with department managers. At the same time, company policies and objectives are explained in detail.

Further formal study is encouraged. Evening schools offer a range of subjects so comprehensive that almost any need can be satisfied.

The men who develop ability to manage have been coached and encouraged by their supervisors on an informal basis. However, a more formal plan of preparing men for the key positions seems advisable. We have under consideration a management development program for our key personnel. This would mean having instructors from a local college, who are especially trained for this purpose, work with us in developing a program. Our objectives would be to develop in the minds of our key people an awareness of what is expected of them in performing their jobs, and to develop the managerial skills of these people. This program will enable managers and supervisors to do their present jobs better, to develop themselves for the assumption of greater responsibility, and to build a stronger and more cohesive team effort.

But can we allow our engineers to enter the halls where business philosophies are determined? The engineer is known for his ability to think precisely, accurately, and imaginatively. But to these basically essential skills the engineer must add additional skills and techniques to qualify as a manager.

Finance, for example, is not foreign to an engineer. It may be considered mathematics dressed up in a different suit. Established forms must be observed, and the significance of interpretations must be known, as they are vital in company plans. The engineer must find a way to become "at home" in finance, just as he must be at ease when "welding" an organization together personnel-wise.

The balancing of an industrial business organization to insure internal satisfaction as well as customer satisfaction is basic in providing for customer good will and future growth. As an illustration of this, sales should not outrun production because, if it does, deliveries will be slow, resulting in customer dissatisfaction.

Many functions of a company organization are assigned to staff or line personnel. Assigning of responsibility is paramount as a management requirement. It is difficult for engineers to do this, as so many engineered products in a small business are the result of efforts of a single individual. The engineer in management must separate himself from this restriction and find the way to share responsibilities. In addition, as a good manager he must weave into the spirit of the organization a desire to do things well.

C. W. Muhlenbruch, of Educational and Technical Consultants, Inc., succinctly states truths pertinent to the subject of the reasoning process of an engineer: "The average engineer graduate is well trained in the *deductive* reasoning process. He can organize problems and formulate plans for their solution. He lacks skill in doing this in the human relations, economics, legal and other business areas, but these skills can be developed. The important thing is that he is well trained in the reasoning process. A fortunate few engineering graduates are able to escape the learning process with a goodly amount of *inductive* reasoning because they possess the very fortunate skill of being able to anticipate problems. They then go on to formulate solutions to the problems and thus are able to work more efficiently at the executive function."

Engineers who are striving for adequacy are being rewarded through a multiplying of opportunities for those fully trained in management.

The engineer–manager finds satisfaction and a better-balanced confidence in a knowledge of the social sciences. The understanding and practice of these social sciences aids in creating an atmosphere of wholesome co-operation. Associates find a highly developed ethical appreciation a healthy influence in realizing growth potential. The individual, in turn, realizes relief from ulcer torment and a more useful place in society.

And this place the engineer is finding so fruitful can be his hallmark if he alerts himself to the social, political, and economic trends. These must be recognized and understood by the engineer as he takes a more active part in the business world as a manager. Never before has the engineer been faced with such opportunities for excellence in the business world. A broad new avenue has been opened for him to attain more truly the full measure and meaning of the professional man.

Navy Mobile Power Plant

Part of a 10,000-kw mobile power plant owned by the U. S. Navy's Bureau of Yards and Docks is now producing power for the people of Mexico City. The equipment was sent to the Mexican capital under a rental agreement to help alleviate a power shortage caused by severe drought and resultant depletion of the water supply in the reservoirs which feed the city's hydroelectric plants.

This is the third time the Navy's power plant has been made available to the Mexican Government for emergency use. Its first trip to Celaya, in the state of Guanajuato, in 1947, provided emergency electric power until the completion of a 10,000-kw steam power plant there.

Its most recent use was at Groton, Conn., where the boiler car was used in connection with preliminary tests of the steam-driven parts of the *U.S.S. Nautilus* before the atomic reactor had been installed.

1956 Lightning Field Investigation on the OVEC 345-Kv System

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The considerable difference between the predicted flashover rate as calculated by the AIEE method and the actual flashover rate on the OVEC system over a 2-year period has forced a re-evaluation of present procedures for estimating lightning flashovers on transmission lines. Data and preliminary conclusions are set forth based on the first year of the field investigation.

ONE OF THE PRIME requisites for the Ohio Valley Electric Corporation (OVEC) 345-kv transmission system is continuity of service. For this reason, extraordinary consideration was given to the lightning performance which could be expected from various proposed line designs. Calculations based upon the accepted AIEE method predicted that the lightning flashover rate for the selected line design should be limited approximately to 0.3 flashovers per 100 miles of line per year.[1] This value results from applying the AIEE method of calculation to a transmission line design, the specifications of which include double-circuit towers such as that shown in Fig. 1, an average span length of 1,300 feet, tower footing resistances no greater than 10 ohms, and insulator strings consisting of eighteen 5¾- by 10-inch insulators.

The OVEC 345-kv transmission system includes approximately 389 miles of double-circuit transmission lines. The first of the seven OVEC lines was placed in service during August 1954, the last line in June 1955. During the period of time between the energization dates for the OVEC transmission lines and January 1957, a total of 80 insulator string flashovers directly attributable to lightning have been recorded on the OVEC system. Thus, the operating experience with these lines for an average of 2 years indicates a lightning flashover rate in excess of 10 flashovers per 100 miles per year.

PURPOSE OF INVESTIGATION

THE TREMENDOUS DIFFERENCE between the predicted flashover rate as calculated by the AIEE method and the actual flashover rate as indicated by 2 years of operating experience could not be explained by standard methods for calculating the lightning performance of transmission lines and by existing lightning data resultant from previous field investigations. In order to re-evaluate the present procedures for estimating lightning flashovers of transmission lines, the American Gas and Electric Company (AGE) and the General Electric Company (GE) decided to embark on a joint investigation comprised of theoretical studies, of laboratory experiments, and of a field investigation of the lightning performance of the OVEC system. This article deals only with the field investigation phase of the over-all investigation and is in the nature of an interim report presenting data and preliminary conclusions resultant from the first year of the lightning field investigation. The results of theoretical and laboratory studies associated with the over-all research program are presented in other papers.[2-8]

For 1956, the purpose or specific goal of the lightning field investigation was fourfold, as follows: (1) to determine the location and frequency of occurrence of lightning strokes to the OVEC transmission system, (2) to obtain additional data regarding current crest magnitudes and wave shapes associated with lightning transients, (3) to utilize new lightning measurement devices designed to indicate maximum lightning current rate-of-rise or insulator voltage wave shape, and (4) to correlate cases of insulation flashover with values of lightning current crest magnitudes and maximum rates-of-rise and with measured voltages across the insulator strings in order to determine the necessary and sufficient conditions for insulator flashover on the OVEC system.

INSTRUMENTATION

Magnetic Links. Measurement of high-magnitude, short-duration electric transients such as those associated with lightning strokes is difficult to accomplish accurately as well as economically on large-scale transmission systems. Of the multitude of devices developed during the years for the measurement of lightning current surges on transmission systems, only the magnetic link has proved to be an economic means of collecting large amounts of information in a relatively short period of time. Although the quality of data obtainable with magnetic links has limitations, particularly in terms of individual records, economic considerations of this field investigation required the use of these links in preference to any more-elaborate measurement device. Inasmuch as the results of many lightning investigations in past years have been based on data acquired by use of

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R. H. Schlomann and W. S. Price are with the American Gas & Electric Service Corporation, New York, N. Y.; I. B. Johnson is with the General Electric Company, Schenectady, N. Y.; and J. G. Anderson is with the General Electric Company, Pittsfield, Mass.

magnetic links, comparison of data obtained during the present investigation with that obtained by previous investigators can be made only if magnetic links have been used in both studies. Thus, in the present field investigation magnetic links were installed to determine the crest magnitudes of current surges resultant from lightning strokes to the transmission line system. In addition to recording the approximate crest magnitudes of the current surges, the magnetic link results indicated the location of lightning strokes and the order of magnitude of the frequency with which lightning strokes contacted the transmission system.

Surge Current Rate-of-Rise Recorders. Because data pertaining only to location, frequency, and crest magnitude of lightning surges can be recorded by magnetic links, the determination of surge wave shapes required the use of supplementary measurement devices. Two such instruments were developed for the present lightning study and were installed on the OVEC system. The first of these devices is called the surge current rate-of-rise recorder.

A photo of this recorder used to measure the maximum rates-of-rise of lightning currents is Fig. 2. This device was a modified design of the Swedish ASEA (Allmana Svenska Elektriska Aktiebologet) recorder used by Hylten-Cavallius and his co-workers in field investigations of lightning in Sweden.[9] The changing magnetic field around a current-carrying conductor was used to induce a voltage in a nearby coil of wire. This coil voltage was impressed across a special explosive gap and, if the rate-of-change of current and magnetic field was high enough to produce about 2.5 kv across the gap, the gap exploded, producing a permanent indication

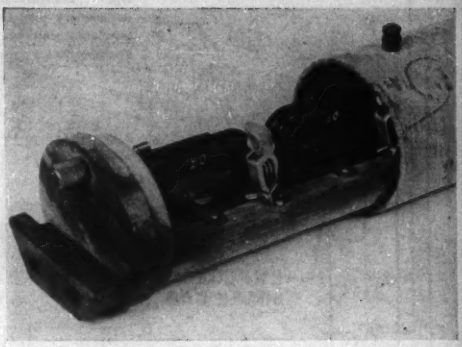

Fig. 2. End view of surge current rate-of-rise recorder with coils partially withdrawn from the recorder housing. Explosive gaps not inserted in gap holders.

that the voltage had exceeded the gap detonation level. Every rate-of-rise recorder contained four coils, each having a different number of turns. Thus, for any given current rate-of-rise some gaps exploded while others did not. In this manner, the order of magnitude of the maximum rate-of-rise of surge current was indicated.

For the configuration shown in Fig. 3, the gap voltage produced by the changing magnetic field linking any given coil is

$$V = -2\,NB \times 10^{-7} \ln\left(\frac{A_2}{A_1}\right) \times \frac{dI}{dt} \qquad (1)$$

where dI/dt equals instantaneous rate-of-change of conductor current in amperes per second.

N = number of turns
B = coil length in meters
V = gap voltage, volts

A sketch of the explosive gap used in these instruments is given in Fig. 4. The gap consists of spherical electrodes separated by a layer of lead trinitroresorcinate explosive. A spark between electrodes ignites the explosive which destroys the gap and its plastic case.

Each explosive gap is held in a holder made of an insulated battery clip which is rugged enough to withstand the gap explosion. After the explosion blows the gap case clear of the clip jaws, the clip spring forces the jaws closed and short circuits the coil that caused the explosion. This eliminates the possibility of severe open circuit voltages produced across the coil by subsequent surges.

A series of tests was run on the explosive gaps to determine average breakdown strengths and the statistical variation between gaps. The conclusion from these tests is that the gaps are somewhat wave shape sensitive, and that the variations in gap strength within any given gap population may be considerable, but that they are sufficiently consistent to give a rough picture of the coil voltages. In any case, it would appear that their

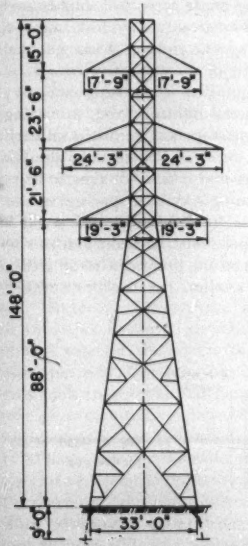

Fig. 1. Typical 345-kv suspension tower.

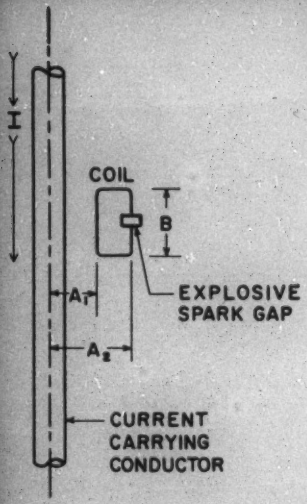

Fig. 3. Dimensional designations used to calculate voltages across explosive gap.

response is comparable to that of Lichtenberg figure recording methods.

Initial calibrations of the recorders with gaps in place were made by a high-current impulse generator which produced an oscillatory current wave having a period of about 30 microseconds and rates of current rise as high as 40 kiloamperes per microsecond (ka/μsec). The current was passed through either a 1¼ inch steel lighning rod or through a ground wire, and the recorder was placed in the same position relative to the current-carrying conductor that it occupied in the field tests. Calibration curves for the recorder coils indicate mean values of 8, 15 and 33 ka/μsec respectively, for the three most sensitive coils. The fourth coil could not be calibrated directly because it required current rates-of-rise exceeding that of the impulse generator. A mean value, however, for this fourth coil was calculated to be 56 ka/μsec. All coils were checked at lower voltages by electronic methods to determine coil response to both slow and fast waves. The coil response was excellent, even to fractional microsecond surges.

Voltage-time Recorders. The second supplementary type of measurement device developed and installed on the OVEC system was called the voltage-time recorder and has been described in a previous paper.[10] The device was used in very limited quantities in an attempt to determine the magnitudes and wave shapes of transient voltages impressed across insulator strings as a result of lightning strokes to the transmission system.

THE FIELD INSTALLATIONS

The OVEC 345-kv transmission system is so large that a complete coverage of the system for a field lightning investigation is economically unfeasible. Equipment and personnel availability for the present study indicated that no more than approximately 5% of the 389-mile system could be included in the 1956 investigation. With this extreme restriction imposed, geographical location of the portion of the system to be sampled was difficult. The OVEC transmission lines are situated in an area roughly 200 miles long from east to west and 15 miles wide from north to south. Most of the terrain is hilly farm- or woodland and some of the area included is not easily accessible. Thunderstorms in the OVEC territory follow a rather well-defined path, with the majority of storms traveling in a northeasterly direction. Isokeraunic levels throughout the system range from 40 to 50.

From the inspection and ease of maintenance viewpoint, a continuous section of transmission line was desirable for the OVEC lightning investigation. Unfortunately, no one 20-mile line segment could be considered as representative of the entire system. In order to obtain better sampling, therefore, four geographically and topographically diverse sections were selected for the investigation. Each of these four sections consisted of a 20-tower segment of line, approximately five miles long, with a total east–west coverage of about 100 miles of the OVEC system.

Three of the four test sections were equipped only with magnetic links; the fourth 20-tower section was equipped with magnetic links, current rate-of-rise recorders and voltage-time recorders. The basic magnetic link installations were identical for all test sections, with two sets of links located on each tower and two more sets of links installed on the ground wire, one set being on each side of the tower. Magnetic link brackets designed to hold two links each were installed on diagonally opposite tower legs in such a manner that the inner link and the outer link spacings from the center of gravity of the tower leg angle were 3.35 inches and 9.35 inches, respectively. The ground wire link brackets were designed to locate magnetic links at 3.5 inches and at 12 inches from the center of the ground wire.

In the test section equipped with supplementary measurement devices, a special lightning rod, extending some 21 feet above the tower top, was mounted on each of the 20 towers. At each tower in this section, a surge current rate-of-rise recorder and a set of magnetic links were installed on the lightning rod. The spacings of the links from the center of the lightning rod were set at 8 inches and 24 inches, respectively. Current rate-of-rise recorders were also located on the ground wire on either side of each tower in the section. Because the number

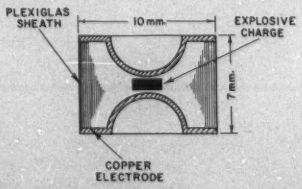

Fig. 4. Sketch of explosive gap.

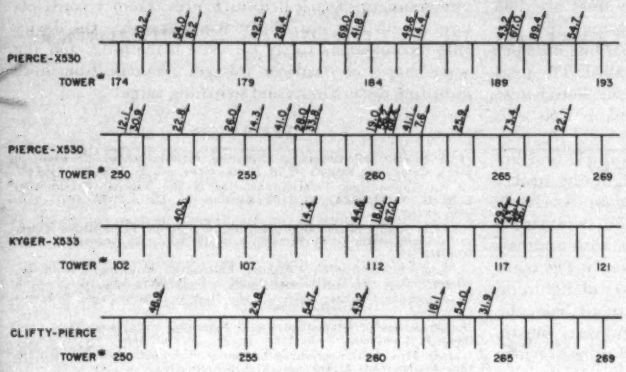

Fig. 5. Summary of lightning stroke locations and current crest magnitudes.

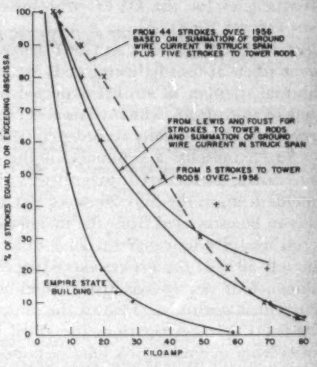
FROM 44 STROKES, OVEC 1956 BASED ON SUMMATION OF GROUND WIRE CURRENT IN STRUCK SPAN PLUS FIVE STROKES TO TOWER RODS
FROM L.E.WIS AND FOUST FOR STROKES TO TOWER RODS AND SUMMATION OF GROUND WIRE CURRENT IN STRUCK SPAN
FROM 5 STROKES TO TOWER RODS OVEC-1956
EMPIRE STATE BUILDING
% OF STROKES EQUAL TO OR EXCEEDING ABSCISSA
KILOAMP

Fig. 6. Percentage distribution curves of lightning current magnitudes.

of voltage-time recorders available for the 1956 investigation was limited, only four such devices were installed. These were located on top crossarms of the Pierce-*X530* No. 1 circuit at towers 176, 183, 191, and 197.

SUMMARY AND DISCUSSION OF RESULTS

Data Obtained. In the four 20-tower sections under observation, only one flashover occurred. This insulator flashover took place while the line was de-energized for maintenance, hence, no relay records were obtained. From magnetic link readings, the probable cause of flashover was determined to be a lightning stroke to the ground wire having a crest current magnitude of approximately 22.8 ka, as determined by simple summation of ground wire currents measured at each end of the stricken span.

In 1956, a total of 49 separate cases of insulator flashover caused by lightning disturbances was recorded for the OVEC 345-kv transmission system. Approximately 70% of the flashovers involved only the top phase, 25% involved only the middle phase, and 5% involved more than one phase or were not well defined. A breakdown of the recorded flashovers according to the lines which were affected indicates the flashover rates for 6 of the 7 OVEC lines show little variance, with an average value of approximately 14 flashovers per 100 line miles per year. Kyger-*X533*, however, experienced only one case of insulator flashover in 1956 and, thus, lowered the annual rate for the system to 12.60 flashovers per 100 miles per year. Combination of the 1956 operating records with those obtained previously on the OVEC system give cumulative flashover rates that range from 7.42 flashovers per 100 miles per year for Kyger-*X533* to 14.33 flashovers per 100 miles per year for Pierce-*X-533*, a system average of 10.66 flashovers per 100 miles per year. Furthermore, the cumulative figures indicate the possible existence of a trend for different areas of the system to have different flashover rates, with the eastern lines from Kyger Creek to the Atomic Energy Commission (AEC) plant having the lowest flashover rate and the lines between Pierce and the AEC plant having the highest flashover rate.

Inasmuch as 6 out of 49 flashover records indicate flashovers at adjacent towers, the adequacy of shielding provided by the single ground wire is being scrutinized. Whether or not shielding failure is responsible for 12% of all flashovers cannot be ascertained fully until more data become available from further field investigation.

Lightning Stroke Frequency and Magnitude. During 1956, a total of 44 lightning disturbances were recorded in the 20 miles of OVEC transmission lines equipped with measurement devices. A method for determining the probable frequency of lightning strokes to any given transmission line has been discussed by Golde.[11] In this method, the total earth surface area shielded from lightning by the towers and the ground wire system of a transmission line is calculated, and the result is compared with the normal stroke density of the locale traversed by the line in order to obtain the number of lightning strokes intercepted by the transmission line. For the OVEC system, Golde's equation for the total area shielded per span of line is:

$$A = [3.6 \pi h_t^2] + [3h_0 (L - 3.2h_t)] \qquad (2)$$

where

A = total area shielded in square feet
h_t = total height of tower in feet equals 148 feet
h_0 = average height of ground wire in feet equals 130 feet
L = average span length in feet equals 1,300 feet

Stroke density in the OVEC territory is approximately 22.5 strokes per square mile per year, based upon an isokeraunic level of 45 and Golde's relation that the stroke density roughly equals one half the isokeraunic level.

With the foregoing assumptions, the expected stroke

frequencies for the OVEC transmission lines are 1.86 strokes per line mile per year if no lightning rods are installed on the towers and 2.04 strokes per line mile per year when 21-foot lightning rods are installed. The total annual number of strokes expected on the four 5-mile test sections is 38, which compares reasonably well with the 44 strokes actually recorded in 1956.

Fig. 5 presents a summary of the locations and approximate crest current magnitudes of lightning strokes incident upon the four 20-tower test sections. As closely as can be estimated from the magnetic link data, stroke crest magnitudes ranged from 7 to 89 ka, with approximately 50% of the strokes exceeding 38 ka. In Fig. 6 are shown four percentage distribution curves of lightning current magnitudes. Two of the curves result from the 1956 OVEC investigation, the third represents the results from magnetic link data obtained during previous investigations on lower voltage systems, and the last distribution curve is based on cathode ray oscillograph data obtained from lightning investigation at the top of the Empire State Building.[12,13] These curves indicate:

1. A generally good agreement between data obtained from stroke currents to tower rods and those obtained by adding ground wire current at each end of the struck span to give the stroke current.
2. A generally good agreement between results obtained with magnetic links on the OVEC 345-kv transmission lines and the data obtained in previous years on lower voltage systems.
3. A general disagreement of the order of or in excess of 2 to 1 between the magnetic link data from tower rods and ground wires of transmission lines and the oscillograph data from the Empire State Building. A suggested correlation of these and other differences among stroke current data is discussed in a companion paper.[7]

Current Rates-of-Rise. Surge current rate-of-rise recorders registered 32 operations during 1956 for the 5-mile section of line in which they were installed. The recorded data show that at least three current surges had rates-of-rise exceeding the upper limit measurable by the rate-of-rise recorder. (All four gaps were detonated.) Two of these surges correspond to probable strokes to the ground wire and the remaining one results from a lightning stroke to one of the lightning rods. In each instance, direct comparison of the indicated rate-of-rise and of the recorded current crest magnitude tends to substantiate the possibility of relatively short front times for the current surges. In no case, however, did insulator flashover result from lightning disturbances measured by rate-of-rise recorders; thus, from data obtained to date the excessive flashover rate of the OVEC transmission system cannot be attributed directly to high current rates-of-rise.

Voltage-Time Recorder Indications. Field experience with voltage-time recorders to date has been limited. Although four recorders were installed by the end of the 1956 lightning season, only one of these was exposed to any transient electrical disturbances. From records obtained with this instrument it appears that the device will record satisfactorily the crest magnitudes and the wave shapes of insulator voltages resultant from both lightning disturbances and switching surges.

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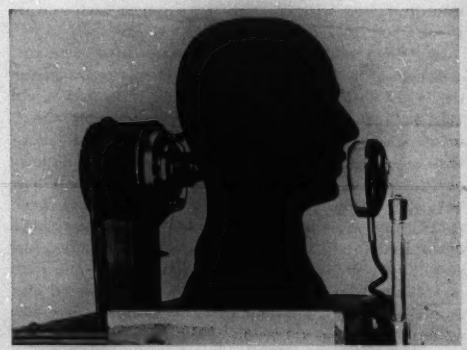
Transistorized Microphone



"Oscar," a life-size artificial head, is used to test a transistorized microphone under approximate conditions of actual use. Shure Brothers, Inc., Evanston, Ill., developed the magnetic microphone for mobile radio transmitters to meet the need for increased intelligibility and reliability in today's overcrowded radio frequency bands.

Component Minimization in Electronic Switching

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ASSOCIATE MEMBER AIEE

SWITCHING CIRCUIT SYNTHESIS presents two basic problems to the engineer. First, he must be able to obtain a circuit which will function according to the input–output specifications. Second, the circuit must be economical in the use of switching components.

The problem under consideration can be stated as follows: given a Boolean function, find an algebraic form of this function such that the circuit realization of this algebraic form requires a minimum number of circuit components.

In this paper, minimization is considered only for those circuits in which diodes or transistors are used as switching elements.

Switching circuits are commonly specified by means of a table of combinations as shown in Table I.

Let it be required to obtain a circuit having the logical structure of Table I. The Boolean function describing this logic is

$$f = X'_2X'_1X'_0 + X'_2X_1X_0 + X_2X_1X'_0 + X_2X_1X_0 \qquad (1)$$

Equation 1 can also be written as

$$f = X'_2X'_1X'_0 + X_1X_0 + X_2X_1 \qquad (2)$$

or as

$$f = X'_2X'_1X'_0 + X_1(X_0 + X_2) \qquad (3)$$

In each of the circuits which result directly from equations 1, 2, or 3, the number of switching elements required is equal to the sum of the number of factors and the number of terms in the corresponding form of the Boolean function.

For circuit realization using diodes or transistors, the "minimal" algebraic form of any Boolean function is that form in which the total number of terms and factors is a minimum.

It is always necessary to minimize both canonical forms of a Boolean function, because these two minimizations result in two distinct algebraic forms, one of which may require fewer circuit components than the other for realization.

The minimization of a canonical form of a Boolean function for circuit realization can be divided into two parts: (1) removal of unnecessary terms and factors from the canonical form; and (2) factoring this result of (1).

Each term in the "sum of products" canonical forms of f and its complement f' can be represented by an octal number. To calculate the octal number representing a given term in the canonical form, the variables in the term are first partitioned into sets of three. Each such set will determine one of the octal digits. All primed variables are given a weight of 0, while the unprimed variables are given a weight of 4, 2, or 1, depending on the position of the variable within the set.

Table I. Table of Combinations

Inputs			Output
X_2	X_1	X_0	f
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

Example: The octal number representing the term $X_7X_6X_5X_4X'_3X'_2X_1X'_0$ from a canonical form involving eight variables is obtained as follows:

X_7X_6,	$X_5X_4X'_3$,	$X'_2X_1X'_0$	
2 1	4 2 0	0 2 0	Weights
3	6	2	Sum of weights

Thus, the octal number 362 represents this term.

Rolf Mueller has shown that a nonredundant "sum of products" form of a Boolean function can be obtained from the first canonical form of the function by performing a series of simple arithmetic operations on the numbers which represent the terms of the canonical form. This procedure can be applied to both canonical forms.

Although no systematic method of factoring Boolean functions to yield the minimal algebraic form is known, circuit components can be conserved by recognizing common factors when they appear in the minimal unfactored form of a Boolean function. The saving z in the number of switching elements which is achieved by any given factoring operation can be determined from the equation

$$z = (r-1)p + k - 2 \qquad (4)$$

where r is the number of terms which contain the common factor, p is the number of variables in the common factor, and k is the number of terms containing the common factor with only one additional variable. The only practical case in which z will be negative (meaning that factoring increases the number of components required) is when $(r,p,k) = (2,1,0)$. Hence, when one variable is a common factor in two terms both of which contain at least three variables, this common factor should not be factored.

If more than one factoring operation upon the minimal unfactored form of a Boolean function is possible, then it becomes necessary to determine the order in which the factoring operations should be performed. No satisfactory solution to this problem is known except for the cut and try process.

Digest of paper 58-3, "Minimization of Components in Electronic Switching Circuits," recommended by the AIEE Electronics Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Communication & Electronics*, 1958.

T. J. Beatson is with the General Electric Company, Palo Alto, Calif.

John K. Hodnette 1957 Edison Medalist

" . . . for his significant contributions to the electrical industry through creative design and development of transformer apparatus which marked new advances in protection, performance and service. For his vision, judgment and management skill which fostered and achieved the practical application of his ideas with resulting advancements in the electrical industry."

Medal History

ELGIN B. ROBERTSON
FELLOW AIEE

THE EDISON MEDAL was founded by an organization of Thomas A. Edison's associates and friends, who hoped that it would serve "as an honorable incentive to scientists, engineers and artisans to maintain by their works the high standard of accomplishment" which had been set by Mr. Edison.

The Medal was established February 11, 1904, and the AIEE was selected as the instrument for making the award. The Institute set up the Edison Medal Committee who made the first award in 1909 to Dr. Elihu Thomson. Today, we make the 47th presentation of the Edison Medal.

The Edison Medal is considered by all as the highest award of the Institute. It has attained this distinction not through hoary tradition, even though its history is a long one, but by the character and the achievements of its recipients.

Mr. President, the Edison Medal Committee members feel that in their selection of John K. Hodnette as the Medalist for 1957 that he will, in joining this list of distinguished medalists, confer even further distinction upon that group.

The Medalist

W. H. SAMMIS
MEMBER AIEE

JOHN K. HODNETTE, who was born and spent his early years on a farm in Alabama, used to recall this little bit of folk lore: On hot days, if you looked out over the fields of that southern farm through the rising heat waves and saw something moving, it was generally a tree stump—not a man.

Partly with tongue in cheek, I claim this borders on calculated deception, for a brief glance backward at his career indicates that he has never been one to be outdistanced . . . by a tree stump, or anything else.

Born March 23, 1902, he was the seventh and youngest child in this rural family and began his early education in the typical one-room school in which the teacher instructed all seven grades as best she could. At the age of about eight, he began such farm chores as milking, plowing, and raising cotton, corn, and sugar cane. By the time he was nine, he was working in a neighbor's cotton fields, earning 40 cents a day to buy a rifle.

John recalls later that from his early childhood he wanted to be an engineer. Anything scientific had a strong appeal for him. This early interest in the sciences received its first real taste of formal education in Macon County High School. The principal was a graduate of Alabama Polytechnic Institute—the college that later was to become Mr. Hodnette's own alma mater. Under his direction, the young student took a full college course in trigonometry and received so much additional instruction in chemistry that he was not required to take chemistry courses in college.

And so it was that this farm boy received his bachelor's degree in mechanical engineering by the time he was 20 years old.

Following graduation, he joined Westinghouse Electric and Manufacturing Company as an assistant in its high voltage laboratory at East Pittsburgh, Pa. This is significant because much of his creative work has been related to high voltage phenomena. In 1926, he was transferred from East Pittsburgh to Sharon, Pa., to which location the company was just moving its transformer operation. Sharon was to be the scene of the major portion of his technical achievements.

It was at Sharon that he began work on his major accomplishments in the field of lightning protection for transformers. One of these studies led to the development of the completely self-protected transformer. The basic patents on this type of transformer were granted Mr. Hodnette and he was responsible not only for the

Presentation and acceptance addresses at the Edison Medal ceremonies held during the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958.

Elgin B. Robertson is Edison Medal Committee Chairman, AIEE Past President, and with Elgin B. Robertson, Inc., Dallas, Texas.

W. H. Sammis is president of the Ohio Edison Company, Akron, Ohio.

original developments, but also for subsequent improvements on this piece of apparatus. His name and the complete self protection of transformers have become synonymous.

Many of you will recall that in the early 1930's, there was not much known about the nature of lightning or the protection of electrical systems and equipment from lightning damage. Transformers were subject to frequent failures from lightning strokes. Such failures were often explained as an act of God. Improved reliability in the form of surge protection and protection against burnouts was a major problem facing electrical utilities. John Hodnette recognized all these problems and began intense investigation to determine the requirements for protecting these systems.

But pioneering in this field could not be accomplished without first developing the tools of the pioneer. Such facilities as current impulse generators and cathode ray oscillographs had to be developed so that lightning, then little understood, could be measured and reproduced in the laboratory. These new tools, testing methods, and advanced techniques enabled John and his associates to double the impulse level of transformers with no increase in insulation thickness.

A better understanding of the characteristics and nature of lightning, coupled with countless investigations of field failures and testing to destruction of large numbers of transformers through the use of man-made lightning led to the development of a new concept of lightning protection. In this new concept, known as Three Point Protection, the transformer tank was used as the ground reference point.

This was first applied to pole type distribution transformers. Three Point Protection gained wide acceptance in the industry, resulting in materially reduced failures caused by lightning. Later, this same principle was applied to power transformers.

The development of a small, effective lightning arrester for use in the protection of distribution transformers was also the product of this engineer-inventor's continuing investigation in the field. This required the development of materials and devices not in use at the time so that a very small, effective arrester could be built to withstand lightning with high current flow reaching 50,000 to 100,000 amperes.

Again parenthetically, when distribution transformers reached this capability, one of his bosses was heard to remark, "We are now prepared to deliver transformers that can take a direct stroke—that is, until the Almighty comes along with a more powerful one."

But the addition of better insulation and protection from lightning did not take care of the entire problem. Utilities were paying a heavy penalty in service interruptions caused by transformer failures from fuse outages. And Mr. Hodnette was aware of this fact from his constant contacts with operators of distribution systems. After an extensive study, he came up with patents covering the completely self-protected transformer and related patents for various components. The key to his improvement was a low voltage breaker which supplanted fuses and protected the transformers against burnouts from overloads.

The significance of this work is indicated by the fact that a majority of the transformers manufactured in this country today incorporate the features of his original developments. These developments came at the time of this country's greatly expanded program of electrification. There is no doubt that his inventions resulted in lower cost and better service to hundreds of thousands of people in this country—particularly for those living in rural areas—who received electrical service for the first time during the 1930's and early 1940's.

John has always been known as a man who can get things done. Witness a situation of some years ago when many of his accomplishments were still before him. The development of the self-protecting transformer was just at a turning point, he thought. Either it would progress rapidly or it would go on the shelf. It should be pointed out that work being done at that time was only on the principle of the self-protecting transformer and even this was considered by some to be impractical.

So, it is not difficult to imagine the degree of skepticism that resulted both within and without his organization when Mr. Hodnette agreed to design and build the first 125 such transformers for the Ohio Edison Company in 1933 and to deliver them in 90 days. Today, it sounds like a classic crash program, and apparently it was. But the round-the-clock drive to meet the commitment was not lacking in either inspiration or perspiration. The transformers were delivered in the promised 90 days and about three fourths of them still are in service today.

It was only logical that the design fundamentals which were so successfully applied to distribution transformers would be extended to power transformers. The improvement in insulation and the development of commercial impulse testing which reproduced actual service conditions not only greatly reduced the size of power transformers, but also made them one of the most reliable pieces of equipment in a utility system.

During the middle and late 1930's he was very active in the development and application of cold rolled oriented transformer core steel to both distribution and power transformers. He led the field in the use of entirely new forms of cores that were adaptable to this new material's characteristics. Such a revolutionary change required very close co-operation among research scientists, the core steel manufacturer, and those involved in the fabrication of cores to get the best possible usage out of the new kind of metal.

This development led to the further reduction in size of large power transformers and contributed a great deal to the ability of manufacturers to make and ship hundreds of transformers ranging from 100,000 to 400,000 kva.

By the time the United States had entered World War II, John Hodnette was engineering manager of the Westinghouse Transformer Division. In 1942, the U. S. Navy asked for industry's help in solving a seri-

ous problem. The United States needed an electrically propelled torpedo—one that would not leave a wake of bubbles to trace the position of the submarine.

The first practical American-designed electric torpedo came out of the Westinghouse Transformer Division just three months after the beginning of design work on the new weapon—in a large measure because of this man's drive. That torpedo was so successful, it is credited with sinking about 2 million tons of Japanese shipping.

Mr. Hodnette was named manager of the Transformer Division of Westinghouse in 1946 and was elected a vice-president of the company two years later. In 1949, he was transferred to company headquarters in Pittsburgh to become vice-president and general manager of industrial products. But before he left the field of transformer design and production to become more involved in the company's executive affairs, he was granted 32 United States patents which have contributed materially to making electric service more reliable in this country.

In 1955, he was elected vice-president and general manager of Westinghouse and in that same year was elected to the board of directors. Just last December, he was elected executive vice-president of the company.

It should be noted in passing that this is not the first time that his accomplishments have been recognized. His own company some 20 years ago awarded him the Westinghouse Order of Merit, the highest honor it can give an employee. When the National Association of Manufacturers observed the 100th Anniversary of the U. S. Patent system, he was named a "Modern Pioneer of the American Frontier of Industry." Our own AIEE conferred the title of Fellow on him some 15 years ago.

In addition to presenting Mr. Hodnette as a distinguished engineer, it is a great privilege and pleasure for me to present him as a close personal friend whom I have known and worked with for more than 20 years. He has been an outstanding citizen of western Pennsylvania; one who has contributed much to the civic development of the area where so many of his technical accomplishments were achieved.

Acceptance

J. K. HODNETTE
FELLOW AIEE

I THANK YOU, Walter, for all those kind and rather embarrassing words in my praise. I don't believe half of what you said, but I am comforted by the well-known fact that praise never hurts anyone—so long as you don't inhale.

Gentlemen, it is hard to express in words my deep appreciation for the award you are conferring on me today. It is particularly hard because I resolved a week ago that one small way in which I could show my gratitude for this honor would be to limit my remarks to about 10 minutes. And I cannot begin to tell you, in that time, how I feel about receiving the 1957 Edison Medal.

I think all of you must already know how I feel. I am deeply moved. I accept the Edison Medal with deepest gratitude and humility.

If this were just an ordinary industry that conferred the award, it would be honor enough. But this is no ordinary industry. This is the electrical industry. This is the industry on which our productivity; our standards of consumption, comfort, and leisure; and our national security is based. It is the industry that stands at the forefront of the American economy for its growths, its technical performance, and the quality of its people. Coming from such an industry, and from such people, the honor is many times the greater.

If I were advising a young engineer on choice of a career today, I think I might tell him of my own experience. I have been privileged to serve the electrical industry for 35 years. In return, this industry has provided me with a livelihood, which perhaps some others might also have done. But it has given me more than that. It has given me real enjoyment in my work and associations. It has made me feel a part of a productive and progressive industrial enterprise. It has allowed me the satisfaction of making the best professional contribution to my country that I am capable of making. Believe me, those are not small rewards.

I would advise the young engineer that, beyond these personal satisfactions, the opportunities are limitless as we are far from reaching the saturation point of technical achievement. Perhaps I can illustrate this by telling you a story of a bright young man who some years ago joined Westinghouse after graduating from college.

Shortly after starting on the student course, he applied to the manager of the Transformer Department for a job. To him the transformer was the most useful, ingenious, challenging, and beautiful machine ever invented by man, and he wanted to design them. He was told to conclude his training course and then he would be considered. But he repeated his request every week for four consecutive weeks. The manager asked him why he persisted in coming back after being advised that he must first complete his training course. He replied, "I have just got to get into that work before they get all the transformers designed."

After all of these years, the job of designing transformers is not finished yet. Even with high-speed computers to make the laborious routine calculations for our engineers, we are still shorthanded.

We have many ways of illustrating the great and rapid technological advances of this industry of ours. The story of what has happened to the size and reliability of transformers probably is the most striking. When you thought of big transformers back in 1923, you meant 10,000- to 15,000-kva single phase. They were capable of taking care of the power requirements of about 5,000 houses. But we were soon working on a real

J. K. Hodnette is executive vice-president of Westinghouse Electric Corporation, Pittsburgh, Pa.

monster—25,000 kva and higher voltage. These were the largest transformers we could ship by rail. We figured the ultimate in size, factoring in design improvements, would be possibly 50,000 kva and would be half the size of a six-room house.

Today it is almost routine to build transformers of 400,000 kva—large enough in capacity to take care of the power requirements of 150,000 houses. But their physical size is very little larger than that of the apparatus of 35 years ago.

Within the next 15 years, the industry will build and use transformers of 750,000 kva—large enough to service almost one third of a million homes. Before we do this, we must once again face the old difficulty—the problem of making a 1973 transformer that can be moved through a 1913 tunnel. I could wish that all the other problems of our industry were as subject to rational analysis and reasonable solution as that one.

Such growth and change have always been distinguishing characteristics of the electrical industry. Today, those qualities are present in such abundance that they offer extraordinary opportunities to those making careers in this field.

Of future growth, we need only to say one thing. During the next 10 years—and perhaps in even less time than that—this nation will install more generating capacity than it has in all the years of our history up to today.

The future opportunity in the industry exists in far greater variety than ever before. The generation of electric power and the manufacture of electric apparatus today cut across the lines of every industry. The electrical industry lies at the heart of three of the four great technological developments of our age—nuclear power, electronic computers, and automatic controls. It will be intimately associated with the fourth development, travel through space.

We face a real challenge if we are to maintain the future development and growth of the industry. You well know that that challenge is the shortage of trained men we need to do the job.

You must have been shocked these past few years as I have been, at the stories and articles stating that the engineer shortage in this country had ended, or was about to end. This is a little like telling General Custer, on June 25, 1876, that he had plenty of troops. Such reports can do—and perhaps already have done—grave disservice to the country at a critical time. They are not true and they will not be true tomorrow. The shortage of engineers will prevail in this country for at least two more decades, until the bulk of the post-war generations have graduated from the engineering schools. The shortage of really creative engineers will be with us always.

The evidence of this is overwhelming. Our labor force in the next 20 years will increase at a rate far below that of a soaring population and of the demand for additional goods and services. To maintain our rate of national growth, we are going to have to increase our productivity per worker by almost two thirds—and the problem will be made harder if the work-week is reduced. That means better machines, and more and better technicians, engineers, and scientists to design, build, maintain, and run them.

As our technology improves and becomes more complex, the need for trained people inevitably rises. In the year I was born, industry employed one technically trained employe for every 400 workers. Today, the ratio is 1 for every 40 workers, and in some individual companies it is 1 for every 10 to 20. In our atomic power work at Westinghouse, one person out of every five is an engineer or a scientist.

It seems to me that such work as this—that such a future as we can promise in a growing industry—can be sold to young engineers in search of a career. It can be sold on its merit and it can be sold on its glamour. Our industry is a stable industry that has been around for a long time; but we are entering new fields and are using new techniques. Our work—yours and mine—can produce the interest and the glamour, the challenges and the results, that attract the best young men.

It behooves us to make these points often and eloquently. We should make them as individuals and as industry representatives. The great professional societies of our industry, such as the one that is meeting here today, should make these three points over and over again for all of us:

1. That the future of the electrical industry of this country has no ceiling.
2. That the electrical industry needs more engineers, and more engineers of the highest quality.
3. That the work these engineers will perform is as vital, as challenging, and as rewarding as any work they can do.

In closing, let me express my appreciation once again to the members and the officers of the AIEE, and to your award committee of the Edison Medal. The memory of this occasion will be with me for a long time to come. Thank you very, very much.

Former Edison Medalists

Elihu Thomson	1909	Willis R. Whitney	1934
Frank J. Sprague	1910	Lewis B. Stillwell	1935
George Westinghouse	1911	Alexander Dow	1936
William Stanley	1912	Gano Dunn	1937
Charles F. Brush	1913	Dugald C. Jackson	1938
Alexander Graham Bell	1914	Philip Torchio	1939
Nikola Tesla	1916	George Ashley Campbell	1940
John J. Carty	1917	John B. Whitehead	1941
Benjamin G. Lamme	1918	Edwin Howard Armstrong	1942
W. L. R. Emmet	1919	Vannevar Bush	1943
Michael I. Pupin	1920	E. F. W. Alexanderson	1944
Cummings C. Chesney	1921	Philip Sporn	1945
Robert A. Millikan	1922	Lee de Forest	1946
John W. Lieb	1923	Joseph Slepian	1947
John W. Howell	1924	Morris E. Leeds	1948
Harris J. Ryan	1925	Karl B. McEachron	1949
William D. Coolidge	1927	Otto B. Blackwell	1950
Frank B. Jewett	1928	Charles F. Wagner	1951
Charles F. Scott	1929	Vladimir K. Zworykin	1952
Frank Conrad	1930	John Findley Peters	1953
E. W. Rice, Jr.	1931	Oliver Ellsworth Buckley	1954
Bancroft Gherardi	1932	Leonid A. Umansky	1955
Arthur E. Kennelly	1933	Comfort A. Adams	1956

Treeing Effects in Polyethylene

D. W. KITCHIN
ASSOCIATE MEMBER AIEE

O. S. PRATT

"Trees," or microscopic channels extending partly or wholly through a wall of insulation, represent a characteristic form of latent damage. Results are given of studies made on this phase of dielectric breakdown in polyethylene.

IT IS quite common for regions which have withstood several previous stresses to fail at much lower voltages. This is not a case of "fatigue," inasmuch as the insulation does not recover its initial dielectric strength even after a long rest. A striking case of this was noted 20 years ago in an experiment in which a 2,000-foot length of rubber-insulated wire was subjected to alternating stress. After each breakdown, the portion which failed was lifted out of water, and stress again was applied to the remaining length. Without latent damage, the successive breakdown values should form an increasing, or at least a nondecreasing, sequence. The average breakdown was about 15 kv, the maximum about 30 kv rms. In most cases, any breakdown at the higher voltages was followed by one or more at considerably lower voltages. At one stage, there were six successive breakdowns between 1 and 5 kv. To test the idea that there were actually six minute channels through the wall, a short section of this wire was punctured with a needle in 12 places. When this sample was stressed, it required 12 successive voltage applications to break down these channels. Thus, the actual failure is a "sacrificial" one which saves the other weak regions temporarily by breaking down first.

Because the rubber insulation was opaque, the suspected damage could not be observed visually and, at the same time, it could be only a matter of conjecture. The discovery of "trees" in polyethylene insulation after prolonged, rather low stresses stimulated interest in this phase of dielectric failure. Because of its nearly transparent nature, polyethylene lends itself especially to such studies.

It is well known that partial breakdown in thick walls of insulation can be readily produced by using sharp points as electrodes. This is discussed from both theoretical and practical viewpoints in an excellent comprehensive paper by J. H. Mason.[1] In a later two-part paper,[2] Mason deals with the whole subject of dielectric breakdown. These papers give extensive references to other work documenting the principles discussed.

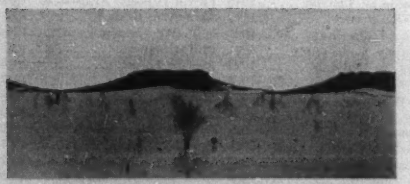

Fig. 1. Trees in contaminated polyethylene after 21 months at 68 volts per mil (60 cycles rms). Wall is 0.170 inch thick.

In the study of breakdown caused by treeing, it is of great interest to follow the complete process visually under the microscope. This was done by embedding needle electrodes in small slabs of polyethylene and placing them on the microscope stage in a suitable holder. By controlling the applied voltage, it was possible to start tree growth, speed up or stop the propagation at will, and take photomicrographs at any desired stages.

When many experiments of this sort are made, it becomes more and more evident that in the majority even of ordinary breakdowns the mechanism is similar, i.e., the final breakdown is preceded by treeing. It is obvious that the final burning may be so severe that all traces of a tree are destroyed. This is especially likely in factory tests on reel lengths of cable. In these instances, the large amount of energy stored in the capacitance discharges through the fault. It may also be true that vestiges of trees in failed spots often escape detection simply because no one looks for them under the microscope. It is surprising how many have been found in the course of this study since the experiments with needles prompted such a search. When the breakdown tests are made on polyethylene cable samples, it is worth while to examine sections containing the fault. It is often possible to note the direction of propagation and even the starting point of a tree associated with the fault. This may aid in determining the probable cause of failure at this point.

Much excellent work on dielectric breakdown, both experimental and theoretical, has been published by others. It is hoped that by describing a method of observing tree-type breakdown in progress, and by exhibiting striking examples of treeing in ordinary breakdowns, this article can make a useful contribution to the subject.

EXPERIMENTAL RESULTS

MASON[2] speaks of the propagation of discharges in fine channels, causing failures in minutes, seconds, or even

Essentially full text of paper 58-121, "Treeing in Polyethylene as a Prelude to Breakdown," presented at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Recommended for publication by the AIEE Dielectrics Committee. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

D. W. Kitchin and O. S. Pratt are with the Simplex Wire & Cable Company, Cambridge, Mass.

Fig. 2. Trees (approximately 30X magnification) starting from fiber in insulation shown in Fig. 1.

microseconds. Conceivably, the time required for failure after initiation of a tree could extent to days, weeks, or months. The rate of advance depends on the stress, thickness, and other factors.

The presence of trees in various stages of development in Fig. 1 supports this view. Figs. 1 and 2 show insulation cut from the 0.170-inch wall of an experimental polyethylene cable after it had been stressed 21 months at 68 volts per mil average (60 cycles rms). Inasmuch as this cable was made originally only to test certain design and production features, it was insulated with scrap polyethylene that proved to be badly contaminated. This was fortunate for the purpose of the present study because as an afterthought, it was put on voltage life test. As a copious source of all sorts of trees, it has been a stimulus to the present study.

The trees start from both inner and outer surfaces and also from solid particles and fibers. Fig. 2 shows a close-up of a fiber and the trees initiated by it. This fiber lies parallel to the conductor. This is because the shearing forces during extrusion orient long thin bodies this way. Radially oriented, it would be quickly disastrous to dielectric strength. Fig. 2 shows that such a fiber represents a decided hazard even though the effect is delayed.

SOLID CONTAMINANTS REVEALED BY STRETCHING

Fig. 3 compares some of this insulation with polyethylene of better quality. Many of the particles that show up here would be invisible in a simple section. The intensification is produced by cutting sections about 40 mils (1 mm) thick and slowly stretching them down to about 4 mils. This produces the symmetrical conical vacuoles ("wind-socks"). The air-spaces show up dark under the microscope because of the difference in refractive index.

EXPERIMENTS WITH NEEDLE ELECTRODES

Fig. 4 shows trees produced by pushing a needle about 1/16 inch into the 0.230-inch wall of a polyethylene-insulated cable and applying 15 kv a-c between this and the conductor for 2 minutes. The needle was forced out by the gases generated. In all later work, it was necessary to clamp the needles to prevent their ejection when treeing started. The trees appear dark by transmitted light, but unless otherwise stated they are actually transparent and look bright by reflected light. Making trees in this way was obviously a haphazard method in which it was impossible to observe the process.

Fig. 5 shows the sample holder for observing treeing and breakdown continuously under the microscope. One needle is connected to the high voltage through 10 megohms; the other needle and the microscope are grounded.

Fig. 6 shows a tree starting from the positive needle and reaching almost to the negative grounded needle after 10 minutes at 20 kv direct voltage. The positive needle appears much sharper, but this is probably one of the frequently observed cases where the polyethylene splits apart just ahead of the needle. This occurs intermittently as a needle is progressively thrust in. Mason states explicitly, and it has been the experience in this study, that breakdown or tree formation takes place at lower stress on the positive point.

Figs. 7 and 8 are photomicrographs selected from sequences showing the progress of tree breakdown with 60-cycle stress. The direction of the branches or "twigs" clearly shows the origin and direction of the trees. The first main branch in Fig. 7 has reached the second needle. Just before the second picture, the voltage was applied again momentarily. The heat melted the polyethylene and sealed this channel off. Meanwhile, a tree has started from the upper needle

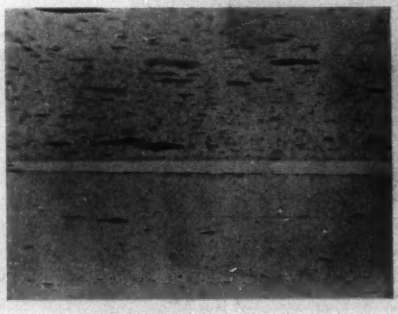

Fig. 3. Contamination in polyethylene revealed by stretching. (Upper) Severe contamination. Same insulation as in Fig. 1. (Lower) Slight contamination in superior insulation.

and met a partner from the lower needle. The final complete puncture followed this channel except for the loop on the right. Fig. 8 gives a better picture of the successive stages in a similar experiment. Even though the burnout was not very severe, only a small tree is left. This suggests that in many cases a tree originally present can be destroyed. The lighter balloon-like figure is called a "heat halo." The heat from the arc produces a change in the texture that persists. This effect can also be seen in Figs. 14, 15, and 16. The heat halo in Fig. 15 is not around the breakdown channel but is concentric with and inside the interface between extruded layers. Such a circular halo can be produced easily in a piece

of polyethylene insulated wire by stripping the conductor so that it projects about 1 inch, and heating this in a gas flame. A heat halo appears as a light circle concentric with the conductor.

Fig. 9 shows a tree in a slab of unvulcanized Butyl rubber. This was used as a transparent representative of rubber insulation, to show that treeing can occur in rubber in overstressed regions. This result supports the idea that the latent damage in the experiments on the 2,000-foot length of rubber-insulated wire was the presence of trees in various stages of development.

Fig. 10 illustrates a very interesting feature of extruded insulation, namely that the dielectric strength is less in the direction parallel to the conductor than in the radial direction. This is presumably because the shearing forces during extrusion orient the polymer molecules and also any fibers, or long particles or aggregates of particles, in the longitudinal direction. It is common experience in testing molded joints or patches that breakdown occurs frequently where there is "orientation" produced by radial flow in the "flash" or

Fig. 4. Tree produced by needle in 0.230-inch wall of polyethylene (15 kv a-c).

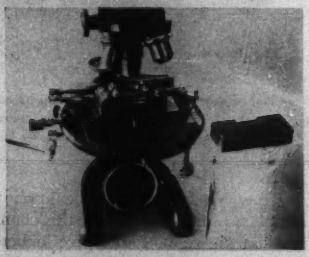

Fig. 5. Arrangement for needle breakdowns under the microscope.

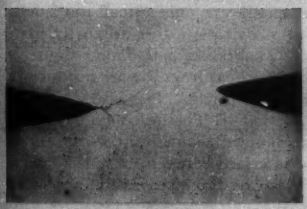

Fig. 6. Tree formed in 10 minutes from positive needle (20 kv d-c).

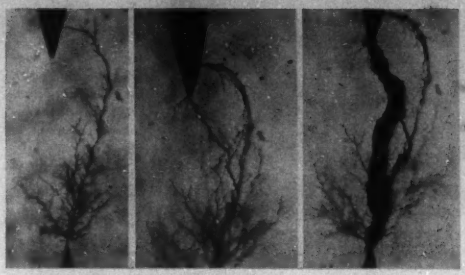

Fig. 7. Three late stages of needle breakdown (a-c).

fins, or where the stock, especially polyethylene, can flow radially into vents or blind holes.

One way to test dielectric weakness in the direction parallel to the conductor would be to cut sections from thick walls of extruded polyethylene and arrange the needless to stress in this direction. Presumably the rate of tree growth would be greater than in the radial direction. The easier method used to obtain Figs. 10 and 11 gave results that seem especially convincing because the channels showed a decided preference for the longitudinal direction although the stress was radial. The sample was no. 15 solid wire with a 62-mil wall of polyethylene. Five needle holes were made and the sample stressed in water 44 hours at 25 kv, 60 cycles rms, without failure. All channels grew initially in a direction parallel to that of extrusion. This could be more clearly seen earlier when there were only a few distinct channels. The edgewise view of the largest tree in Fig. 11 shows that there was little tendency to spread laterally.

TREES ASSOCIATED WITH TEST PUNCHOUTS

In regular breakdown tests it is, of course, not feasible to watch the action the way it was in the needle tests under the microscope. Nevertheless it seems probable, if not certain, that failure is preceded and caused by treeing, wherever any portion of a tree remains. In the pictures in Figs. 12 through 18 there is no doubt about the presence of trees. These pictures were all of punchouts made in regular routine tests, not in special experiments on treeing. They are "post-mortems."

TREES IN SHORT-TIME A-C BREAKDOWN FAILURES

Figs. 12, 13, and 14 show specimens resulting from short-time a-c breakdowns. In all three, the direction of growth of the trees indicates that failures started from the conductor. In Fig. 13, the branches and the final multiple breakdown channels show no tendency to follow the seal mark. This is the interface where the two streams of polyethylene join in the extrusion head after flowing around the tip. It is a little to the left of the breakdown channel. Thus far in this study, no breakdown channels examined have shown any tendency to follow the seal mark. The figures for breakdown and wall thickness are, unfortunately, not available for Fig.

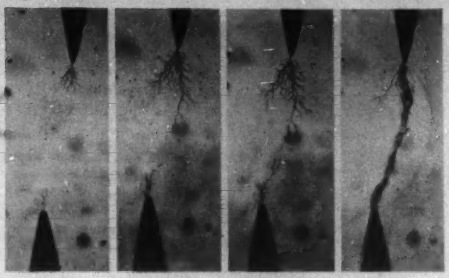

Fig. 8. Progressive needle breakdown (a-c).

13, but the photo is included as a striking example of treeing.

Fig. 14 is interesting because of the well-developed heat halo and the tendency of the breakdown path to follow the direction of extrusion for an appreciable part of its length. This may be related to the lower dielectric strength in this direction discussed in connection with Fig. 10.

Of this wire, 17 samples were subjected to alternating voltages between 25 and 35 kv rms. The times required for failure ranged from several seconds to about 15 minutes. The active length in water was only 3 feet, and a 10-megohm resistor was connected in the high-voltage lead to the conductor to limit the burning. In every case, definite remains of trees were found.

TREES IN D-C BREAKDOWN FAILURES

FIGS. 15, 16, AND 17 show trees produced by direct voltage. In all three, the final stress was about 2,500 volts per mil. The sample in Fig. 15 was a foreign cable insulated in two layers. The light circle near the middle of the wall is the halo produced by the heat from the second layer. The interface is the fine dark line near the outside. In Figs. 15 and 16, the main channels are filled with oil so that they appear white. The oil was used to aid in photographing. It had not yet filled the branches, so they appear black. The polarity used in the test on the sample in Fig. 15 is not known.

Fig. 16 is representative of a set of 15 breakdown samples of core having a solid conductor surrounded by three spiralled copper tapes, to give the equivalent of a no. 6 solid conductor. All were stressed 5 minutes at 200 kv, following which the voltage was raised to 500 kv and held until failure. The water was positive, the conductor negative. Remains of trees were found in each of the 15 samples, and the direction of growth was clearly from positive water to negative copper conductor. Further tests are necessary to show whether this is wholly a result of the polarity, or whether trees start more easily from the water electrode with either polarity.

Fig. 17 shows one of the rare exceptions to this observation. The burned puncture is out of the picture. The channels were black, visible to the unaided eye, and many reached the surface. The starting points all lay along edges of the copper tapes so that the trees spiralled around the conductor. There may have been some defect in the conductor or damage to the insulation in this section. The remarkable feature is the number of simultaneously developed, practically "full grown" trees. The stress was 5 minutes at 200 kv, then a gradual rise to 500 kv, at which potential the failure occurred after 22 seconds. It would hardly be correct to call this a weak section.

TREES IN IMPULSE FAILURES

FIG. 18 IS INCLUDED because it shows treeing associated with impulse breakdown. This is a direct photograph in which the uncut sample was immersed in oil. It was taken at an angle that shows the tree. The breakdown

Fig. 9. Tree from needle in uncompounded Butyl rubber (10 kv a-c).

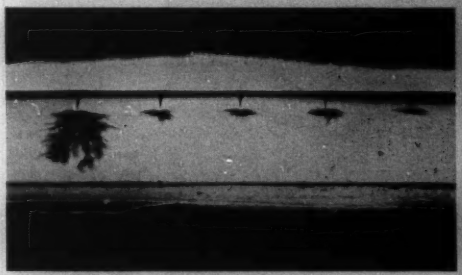

Fig. 10. Trees from needle holes in 0.062-inch wall showing tendency to spread in direction of extrusion.

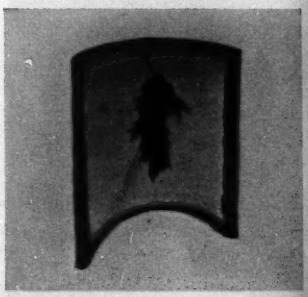

Fig. 11. Edgewise view of largest tree in Fig. 10, showing lack of tendency to spread tangentially.

Fig. 12. Typical tree structure in short-time breakdown test failure (100 kv a-c). Wall is 0.317 inch thick.

Fig. 13. Short-time a-c breakdown with greater branching, and multiple burn-out channels.

Fig. 14. Short-time breakdown path (30 kv a-c) in 0.107-inch wall, showing residues of trees and "heat halo."

Fig. 15. Breakdown path in 2-layer polyethylene (500 kv d-c), showing interface and "heat halo."

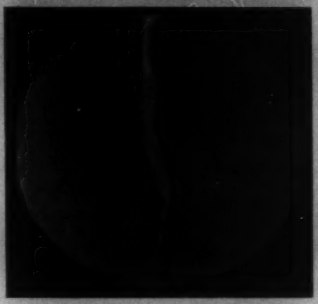

Fig. 16. Fault path in 0.230-inch wall (failed at 500 kv d-c), showing typical direction of tree growth from positive water (top) to negative conductor (bottom).

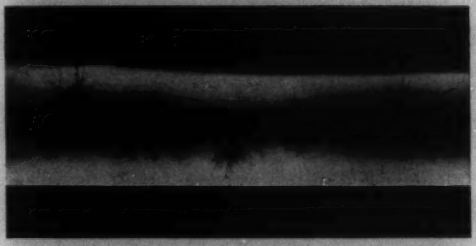

Fig. 17. Rare type of latent damage in another length of the core shown in Fig. 16 after 22 seconds at 500 kv d-c.

Fig. 18. Impulse breakdown channel with associated treeing.

Fig. 19. Peculiar form of latent damage after 16 months at 125 volts per mil (a-c). No. 9 solid wire, 0.100-inch wall.

channel ends at the surface, the tree slightly short of it.

In future work, many impulse breakdown samples will be examined. In this type of failure, one would expect to find much less branching than in trees formed during long periods on low a-c stress.

OTHER TYPES OF LATENT DAMAGE

FIGS. 19 AND 20 show a curious type of latent damage that is quite different from the treeing in the previous photographs. This sample was stressed 16 months at 125 volts per mil, a-c. Although this has not been proved, it seems reasonable to suppose that the condition was produced by the prolonged electric stress and that these regions had some structural characteristics that made them susceptible to this type of action.

Viewed directly, the spots look simply like continuous stained or discolored regions, but when resolved, as in Fig. 20 (35× magnification), they are seen to consist of collections of a finite number of discrete fine black streaks. The appearance can be likened to that of a porcupine. The individual streaks do not start from a branch or even a common point and they appear to be unrelated to each other. Further study may reveal the cause and throw more light on the mechanism of breakdown.

The beautiful tree shown in Fig. 21 and the description of the method of producing it were kindly made available by Dr. J. G. Trump of the Massachusetts Institute of Technology and the High Voltage Engineering Corporation. This specimen was made by irradiating a Lucite slab with 3-million-volt electrons. The beam was normal to the flat surface and nearly uniform over the whole area. The electrons were trapped in the Lucite. The site of the discharge was preselected by making a pin-prick defect in the otherwise polished edge of the block. The discharge pattern tends to lie in the plane corresponding to the average penetration and consequent maximum potential. The estimated electron charge was 50 microcoulombs, producing an internal potential of about a quarter million volts. This may properly be considered a form of latent damage.

SUMMARY

"TREES," or fine branching microscopic channels extending partly or even wholly through a wall of insulation, represent a characteristic form of latent damage. This phase of dielectric breakdown has been studied in polyethylene. The phenomenon is probably similar in other dielectrics, such as rubber, where it cannot be seen so readily.

A method of observing the progressive stages of treeing and final punchout under the microscope has been described.

The similarity between the appearance in the final stage of needle breakdowns after preliminary treeing and that of the breakdown paths from ordinary tests with alternating, direct, or impulse voltage supports the view that, in most breakdowns, the eventual failure is preceded by treeing.

It is probable that the time interval between the start of a tree and the final breakdown can vary from months to microseconds. At low over-all stress, trees may start at points of high local overstress but eventually stop growing. This permits the growth of other trees before breakdown, so that the presence of many trees in different stages of growth is most likely in insulation after prolonged life tests.

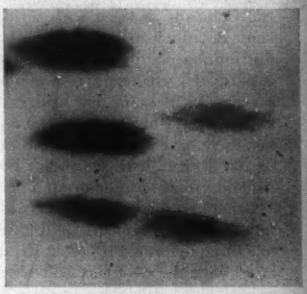

Fig. 20. Close-up showing structure of spots shown in Fig. 19.

At very high stress, the first channel may traverse the wall before others form, and the whole process from tree start to final punchout may require only extremely short periods of time—of the order of microseconds.

Fig. 21. Tree produced by irradiating Lucite with 3-megavolt electrons and discharging at a pinpoint defect.

Regardless of the time scale, the phenomenon seems to be basically similar, in that the tree comes before the punchout.

This quite elementary study is offered in the hope that such a collection of pictures showing the relationship between treeing and breakdown may be of some use in this field of investigation.

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Cable Installations on Bridges

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AS IN THE CASE of other utilities located in densely populated areas, the Philadelphia Electric Company is faced with serious right-of-way problems. Because a major portion of the transmission and distribution plant is in the vicinity of public highways, a particular challenge is presented by the problems associated with many new bridges over railroads, streets, and depressed highways. In the 5-year period now ending, there have been constructed in this territory a total of 200 bridges, with significant potentialities for existing and proposed underground facilities.

Generally, there is enough space in bridge structures for utility requirements, if this space can be adapted to a suitable form. This often required extensive negotiation with the designers and owners of the bridge in co-operation with other utilities desiring space in the structure. Although the problem is particularly active in connection with new structures, there occasionally arises a problem involving the use of existing bridges for cable crossings. The necessity for ingenuity is greater in connection with the old structures.

Because of the many variations in bridge construction and in type of cable involved in the crossings, it has been found that each situation must be approached on an individual basis, although there are certain general principles which appear in all the cases. Some recent experiences in this field are outlined here.

Pipe-Type Cable Installations. The bridge designer usually will insist that no transverse or longitudinal loads be transmitted to the bridge from pipe-type cable installations, so a method of support should be used that will allow for pipe movement which normally exposes the pipe to the atmosphere.

Under these conditions, the design must provide for the thermal expansion and contraction of the steel pipe caused by normal ambient temperature and electric load fluctuations, independent of any bridge movement. The type of installation used most frequently is to suspend or support the pipe on rollers which will permit longitudinal movement. Beyond the bridge an expansion loop is provided to absorb the movement.

Conduit in Steel Structures. Where there are no existing facilities, concrete encased fiber or terra cotta ducts usually are avoided because of the weight involved. Through experience, it has been found that transite ducts offer the most economical installation at these locations. In addition to their light weight and noncorrosive properties, they exhibit strength characteristics which eliminate the need for a continuous steel support or concrete supporting slab. Simple galvanized steel supports can be fabricated with a steel angle and a cover plate bolted on each side to secure the ducts.

Where operating cables are involved, either in highways where new structures are being built or in existing bridges to be reconstructed, continuous service operation is most imperative. At these locations, cables are maintained in a manner which permits the construction of the bridge around the existing cable facilities. A temporary bridge is constructed using steel H-columns driven into the ground adjacent to the conduit run to support I-beams laid on their side to provide a trough for the cables. Conduit is removed and cables are fireproofed and placed in the I-beam, which is filled with sand and covered with wood for protection. When bridge girders are in place, a reinforced concrete slab is cast to support the conduit in its final location. Using split terra cotta ducts, cables are shifted to their permanent location and temporary supports are removed enabling completion of bridge construction.

Conduit in Concrete Structures. A recent construction trend is toward prestressed and post-stressed concrete beams. At present, there are two basic types of girder design, the box type and the I-beam type.

The box type girder is essentially square with a cylindrical void in the center for weight reduction. At locations where there are no existing cables, ducts are cast as an integral part of the prestressed beam in place of the void using 4½-inch fiber or transite ducts with approximately 3-inch separation. Couplings approximately 9 inches long are installed at the ends of each beam and in the abutments with a "floating" section to span joints between the beams and between the beams and abutments to provide for expansion.

Concrete I-beam type structures offer sufficient space for conduit, and conventional methods for supporting conduit are used. Angle iron supports are inserted at suitable intervals using bolt inserts cast in the beams. A concrete supporting slab is installed in a manner similar to the method used in box-type girder construction.

There can be no doubt that further developments will take place in bridge construction as a result of the national highway construction program. Therefore, it appears that more attention will be required to devise adequate methods for accommodating utility facilities in bridge structures if every advantage is to be taken to obtain the lowest costs in the rearrangement of underground plant.

Digest of paper 58-17, recommended by the AIEE Insulated Conductors Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

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Impedance and Return Loss Performance

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THE DESIGN of intercity trunks under conditions of nation-wide dialing and the greater number of permissible links between terminal offices has required a reappraisal of transmission objectives, including terminal return losses.

Return loss is defined as a measure of similarity of two impedances. The nearer these impedances approach identical magnitude and angle, the higher will be the return loss in db. The two impedances of concern here are first, that of the compromise network (600 or 900 ohms + 2 microfarads in the 4-wire terminating sets of intercity trunks, and second, the input impedance of the over-all terminating facilities as seen from the 2-wire side of the terminating set. The problem is to make the heterogeneous array of impedances of the 2-wire metropolitan area plant approach in some manner the impedance of the compromise network over the entire voice-frequency range. To satisfy the present-day objectives, the distribution of return losses in the echo range should have an average of 15 db, and at the singing frequencies should have an average of 10 db. These objectives are 4 db higher than those previously acceptable.

In practically all cases, the metropolitan area plant terminating an intercity call involves a 2-wire trunk to the central office serving the subscriber, and 2-wire loop facilities from that central office to the subscriber station.

The factors affecting the sending end impedance of the trunk are

1. The type of facility which may vary in gage and loading although currently *H88* loading is the recommended type.
2. The repeating coil at the input to the trunk. At the higher frequencies this coil is almost electrically transparent. At the lower frequencies, below 500 cycles, it has an adverse effect.
3. Repeating coil at the far end of the trunk where it exists.
4. The loop that serves as a termination.

Loop impedances vary widely over the frequency range under consideration. These variations at each frequency are caused by the different gages and the wide range of lengths involved. For example, the impedance at 1,000 cycles of subscriber loops close to the central office (practically no cable) will be about 500 ohms with a positive angle of about 30 degrees, whereas the impedance of loops of about 15 kilofeet can vary from 850 to 1,400 ohms with a negative angle of about 30 degrees, depending on whether the gage is 19, 22, 24, 26, or some mixture of these. At other frequencies, this span of impedances varies considerably and is extended at both ends.

Loaded loops provide another variation in the field of loop impedance, but do have the advantage, if properly designed, of improving the impedance as seen from the input of the system by extending the structure of the trunk effectively.

The means taken to achieve impedance control are two. One is the use of a 1-microfarad instead of 4-microfarad capacitor at the midpoint of the input repeating coil, thus providing a 4- to 6-db return loss improvement at 300 cycles, which is important from the singing standpoint. The second measure is the use of an impedance compensator to improve the impedance of the loaded trunk facility at the higher frequencies, giving it a more uniform resistance value. This is important both to the over-all echo and from the singing standpoint at the upper frequency range.

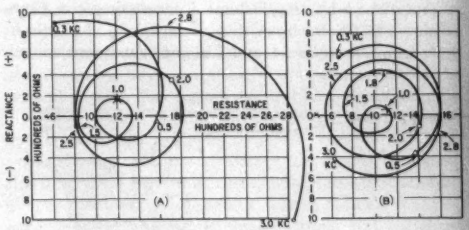

Fig. 1. Input impedance 24-kilofoot 22*H88* trunk, terminated with a 20-kilofoot loop, as frequency is varied from 0.3 to 3.0 kc. (A) Before impedance-improving measures, (B) After impedance-improving measures.

Fig. 1(A) shows the computed input impedances from 300 to 3,000 cycles of a 2-wire termination consisting of a loaded trunk with proper ratio repeating coils at each end connected to a long, nonloaded subscriber loop terminated in a subset.

Fig. 1(B) shows the same layout after the two impedance-improving measures have been applied. At the extremes of the range—that is, the 300 and 3,000 cycle points—the impedances definitely have been brought under control and, in addition, the average impedance has been significantly lowered.

Digest of paper 58-4, "Impedance and Return Loss Performance of Telephone Plant in Metropolitan Areas," recommended by the AIEE Wire Communication Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Communication and Electronics*, 1958.

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Performance of UHF and VHF Transmitting and Receiving Equipment

W. J. MORLOCK W. O. SWINYARD

Television Allocation Study Organization's (TASO) Panels 1 and 2 are concerned with the television transmitting and television receiving equipment arts respectively. The general problems and specific studies undertaken for a critical evaluation of VHF and UHF to obtain data for the FCC are set forth.

FOR AN UNDERSTANDING of the challenging problems that the television industry faces, it is necessary to consider some of the station allocation principles which are involved and which have brought about the present position.

Table I shows the television channel assignments as established by the Federal Communications Commission (FCC). It shows that there are 12 channels in the region between 54 and 216 mc which are considered as the vhf channels; and 70 additional channels from 470 to 890 mc which are classed as uhf.

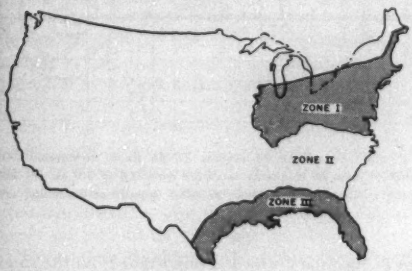

Fig. 1. Zones for television channel allocation purposes.

FACTORS UNDERLYING PRESENT ALLOCATIONS

Grades of Service. In establishing the criteria by which a channel allocation plan could be made, it was necessary first to decide on grades of service. Two grades were specified by the FCC in 1951. Grade A service was considered as providing a picture quality which is acceptable to the median observer for at least 90% of the time at the best 70% of the receiver locations at the outer limits of the service. Grade B service, on the other hand, was expected to deliver this quality of picture to only 50% of the receiver locations at the outer limits of service.

Based on data available at that time, with consideration of such receiving-end factors as noise, antenna gain, and transmission line losses, Table II was prepared giving the required median field strength to provide these two grades of service. Because of receiver problems, as the frequency is increased a greater signal voltage is needed at the receiver input. This is indicated in Table II which shows that twice the voltage is required for Grade A service for uhf as is needed for the low vhf; and that for Grade B service, uhf needs seven times the signal as needed for the low vhf.

Required Desired-to-Undesired Field Strength Ratio. A fundamental philosophy of the allocation plan was to provide the maximum amount of coverage with the number of channels available. This required avoidance of interference to each station's service area from signals of other stations on the same or on other channels.

As a result of a great number of subjective tests, a table was prepared showing the permissible ratio between the median field intensity of the desired signal and the strongest undesired signal for 10% of the time. This is shown as Table III for cochannel stations. Note that this table specifies offset-carrier operation. This means that the carrier frequencies of the geographically adjacent stations (on the same channel) are offset from each other by plus or minus 10 kc. Operation in this manner is found to reduce the effect of the interference by a factor approaching 17 db.

For stations on adjacent channels, it was decided that a zero db (1 to 1) ratio could be permitted between desired and undesired signals, for both vhf and uhf, and for both Grade A and Grade B service.

Allocation Zones. Before setting up the mileage separation requirements to keep the interference low, it was necessary also to consider factors caused by geographical location. Fig. 1 shows a map of the United States as divided into three zones. In zone one, there is a high population density thus necessitating the closer spacing of stations than desirable. In zone three, there is a region where tropospheric propagation often results in interference at unusual distances so that a greater separation between stations was required. The rest of the country was considered as zone two.

Mileage Separation between Stations. With these

A special article recommended for publication by the Television and Aural Broadcasting Systems Committee.

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Table I. Television Channel Assignments

Channel Numbers	Frequency Band	Frequency Range (mc)	Number of Channels in Group
2- 6	vhf, low	54- 88	5
7-13	vhf, high	174-216	7
14-83	uhf	470-890	70

Table II. Grades of Television Service Required Median Field Strength in Microvolts per Meter

Grade of Service	Vhf Channels 2 to 6	Vhf Channels 7 to 13	Uhf Channels 14 to 83
A	2,500	3,600	5,000
B	225	630	1,580

Table III. Permissible Ratio of Desired to Undesired Field Strength for 10% of the Time (Cochannel Operation with Offset Carrier)

Grade of Service	Vhf Channels 2 to 13 (db)	Uhf Channels 14 to 83 (db)
A	34	36
B	28	28

Table IV. Minimum Mileage Separations Between Cochannel and Adjacent Channel Stations

Zone	Vhf Channels 2 to 13		Uhf Channels 14 to 83	
	Co-Channel Stations	Adjacent Channel Stations	Co-Channel Stations	Adjacent Channel Stations
	(miles)		(miles)	
I	170	60	155	55
II	190	60	175	55
III	220	60	205	55

Table V. Maximum Effective Radiated Power

Channel Numbers	Maximum erp Antenna Heights Up to 1,000 Feet above Average Terrain* (kw)
Vhf 2- 6	100
Vhf 7-13	316
Uhf 14-83	5,000

* In zone one on uhf channels and in zones two and three on all channels, the specified powers may be used with effective antenna heights up to 2,000 feet.

ground rules established, it was then possible to specify the minimum mileage separations between stations. This is shown in Table IV and became the basis for the "Table of Assignments." It will be noted that the mileage separations for both vhf and uhf are greater for zone three, and less for zone one, than they are for zone two; and that uhf stations can be located more closely than vhf stations because of the greater signal attenuation of uhf.

Effective Radiated Power Requirements. To provide a good service, the FCC specifies that a certain minimum field strength must be provided over the principal community to be served; and, to avoid excessive interference in the service areas of other stations, FCC also places a maximum on the effective radiated power (erp). Effective radiated power, incidentally, is defined as the actual antenna power multiplied by the power gain of the antenna. Table V indicates these maximum powers. Note that greater erp's are permitted for high channel vhf than for low channel vhf, and that much greater values are permitted for uhf. This is also in recognition of the fact that attenuations are greater at the higher frequencies. The 5,000-kw erp shown for uhf was adopted by the FCC in 1956, previously 1,000 kw having been the maximum.

TRANSMITTING EQUIPMENT PROBLEMS

Antennas. The need to use higher effective radiated powers for the uhf channels is not quite so great a burden as it might at first appear because of the greater ease of achieving antenna gain.

Fig. 2 shows an assembly of a typical antenna of the super turnstile or batwing type which has had widespread use at vhf. A number of bays are stacked approximately one wave length apart and excited approximately in phase to produce antenna gain by concentrating the radiated energy horizontally. However, the radiation pattern at various azimuths around the antenna is essentially uniform. The power gain of this type antenna is about the same as the number of bays used. For high channel vhf, antennas of up to 12 bays are common but at the low vhf channels usually not over six are used because of size and weight.

Fig. 3 shows a uhf antenna of the slotted-cylinder type and Fig. 4 shows one of the helical type. With these antennas, power gains at uhf up to about 50 are practical, although economic considerations and radiation considerations having to do with the narrowness of the vertical pattern may make it desirable to limit the gain to a lower value. Again, the horizontal radiation pattern is essentially uniform.

In standard AM broadcasting, the use of directionalized antennas to reduce interference to other stations is very common. Although it would appear that the same requirement would make directional antennas very attractive for television, there are additional complications at these higher frequencies. This is because the television wavelengths are so small that the waves are more easily reflected by both man-made and topo-

Courtesy General Electric Co.

Fig. 2. Typical super turnstile, or batwing, antenna.

Courtesy RCA

Fig. 3. Slotted-cylinder antenna for uhf.

Courtesy General Electric Co.

Fig. 4. Helical antenna for uhf.

graphical features which would tend to fill in the nulls in the direction to which protection must be afforded. Therefore, the use of directional antennas for the purpose of cutting mileage separation has, in the past, specifically been excluded by the FCC. However, consideration of directional antennas is bound to play an important part in any new allocation plan; so TASO Panel 1 is carefully watching all developments along this line.

WJMR-TV in New Orleans is conducting tests on both uhf and vhf, using a directionalized vhf helical antenna to reduce interference. Fig. 5 is a photograph of this antenna. Fig. 6 shows its horizontal radiation pattern.

Transmitters. The status of the television transmitter art is such that the industry can build almost anything for which there is a sufficient demand. With the erp requirements which have been outlined and with the available antenna gains, it has turned out that the market needs up to now have called for transmitters up to a maximum power of about 50 kw for either vhf or uhf. If it turns out that greater power is required, such equipment can be made available, but operating costs naturally will go up, too. Figure 7 shows a typical transmitter of 25-kw rating and Fig. 8 shows a 50-kw transmitter. Although these are vhf transmitters, the external appearance of a uhf transmitter is similar.

Repeater Transmitters. Panel 1 has a committee working on the interesting problems of "repeater" transmitters. These are very important to any consideration of allocations because of their potential use in filling in a shadow area in the coverage of a transmitter and in providing service to communities which are too small to support a regular station.

In general, three types of repeater transmitters are recognized. There is the "satellite" which operates much as a regular station, on a different channel than the main transmitter, but carrying the identical program. Then there is the "translator" which receives the signal of a vhf or uhf station and translates it (usually by heterodyning) to one of the upper 14 uhf channels. And then there is the "booster" which acts as a powerful linear amplifier to amplify the signal and retransmit it on the same channel. With the booster, it is essential that the input receiving antenna be well isolated from the signal of the booster transmitting antenna.

Another important consideration of the booster is the size of the "mush-area," which is that region where the direct signal from the main station approaches the field intensity of the boosted signal. Use of vertical polarization for the booster is one possibility which is being investigated to see whether the size of this area can be reduced. Measurements are being conducted at Waterbury, Conn., where a uhf booster has been in operation for about two years.

FUTURE WORK OF PANEL 1

THE BACKGROUND and some of the broad general problems of Panel 1 have been treated briefly. Some of the specific studies with which Panel 1 is charged are:

Transmitters. 1. A survey of present equipment output powers at uhf and at vhf, including consideration of initial costs and cost of operation.

2. Present and potential signal-to-noise levels.
3. Reliability of present equipment.
4. Avenues of needed improvement.

Transmitting Antennas. 1. The performance of vhf and uhf antennas of the types now in use with respect

Fig. 5. Directionalized vhf antenna at WJMR-TV.

to power gain, power handling capacity, and radiation pattern.

2. Studies and opinions as to the maximum reliable power gain which can be expected to be achieved.

3. Study of the problem of providing adequate signal coverage at distances close to the antenna when very narrow vertical beamwidths are used.

4. Study of the problem of platform stability requirements in connection with high-gain antennas.

5. Avenues of needed improvement.

Transmission Lines. 1. Line losses.

2. The problems of providing high power handling capacity and low losses to meet the requirements of large radiated powers from antennas at substantial distances from their transmitters.

Note that, in these studies, the present has been stressed; but obviously the same information is needed

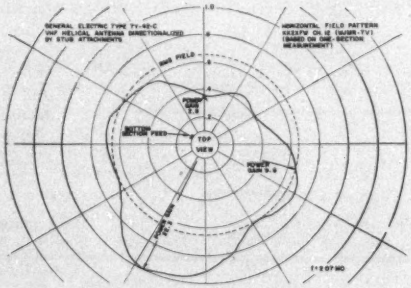

Fig. 6. Horizontal radiation pattern of directionalized vhf antenna at WJMR-TV.

for future equipment. In obtaining such information, Panel 1 must tread lightly because any discussions among manufacturers touching on future designs and prices could run quickly into trouble with the anti-trust laws. The details of getting over this hurdle are being worked out. One solution is for Panel 1 to recommend to the FCC the areas on which such information is required. The FCC can obtain this from the individual manufacturers directly and, after analyzing the data, give to TASO the averages to be integrated into TASO's final reports.

Obviously, Panel 1 has interesting problems, and its four committees, comprising members from broadcasting and from manufacturing, are aggressively working on them. Panel 1 believes that the results of the work of these committees will contribute greatly to TASO's objective of supplying technical information to the FCC on the subject of allocations.

RECEIVING EQUIPMENT

A CONSIDERATION of frequency allocation changes in the assignment of television channels involves economic factors which affect millions of people who are users of

Courtesy Standard Electronics

Fig. 7. Vhf transmitter of 25-kw power rating.

television receiving equipment. At present, over 75% of the 49 million American homes have television receivers. There are over 46 million television receivers in use in this country and to this number between 6 million and 7 million sets are being added annually. The number of color sets in use at this time is about 160,000. Conservative estimates give 1 million as the number which will be in use by the end of 1960. Receiving equipment problems arising as a result of frequency allocation changes are, consequently, of great importance from the standpoint of both users and manufacturers of receiving equipment for both monochrome and color transmissions.

The tasks assigned to Panel 2 (Receiving Equipment) are set down in the TASO Charter as follows:

> "The Panel on Receiving Equipment shall study the status of the television equipment art (monochrome and color). The panel shall recommend specific tasks to be undertaken, looking toward securing reliable information, on both theoretical and practical bases, for the purpose of appraising the present performance of television receiving equipment for both vhf and uhf broadcasting. These studies shall extend to all channels presently allocated to television broadcasting."

Panel 2 has set up the following committees for the purpose of accomplishing its objectives:

1. Separate uhf and vhf Receivers
2. Combination uhf/vhf Receivers.
3. Uhf Converters

Courtesy RCA

Fig. 8. Vhf transmitter of 50-kw power rating.

Fig. 9. Uhf receiving antenna—stacked "V."

Fig. 10. Uhf receiving antenna—rhombic.

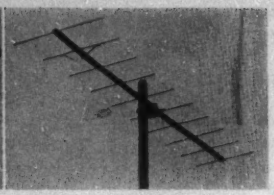

Fig. 11. Uhf receiving antenna—Yagi.

4. Antennas and Transmission Lines
5. Community Television Antennas and Distribution Systems

In this article receiving equipment performance and problems can be considered only briefly. Since Panel 2 has as yet not collected comprehensive engineering data on performance of uhf/vhf receiving equipment, all performance data given in this paper have been independently collected and represent what are believed to be average performance characteristics of present day equipment.

Antennas and Transmission Lines. There are many different types of uhf and vhf receiving antennas. The vhf antennas are well known and the many types available are familiar to everyone. The uhf antennas are not yet as well known. There are bow ties, corner reflectors, Yagis, etc. The Television Factbook for Fall 1957 lists 53 manufacturers of television receiving antennas. Typical uhf receiving antennas are shown in Figs. 9, 10, 11, and 12.

Regardless of the type or configuration of the receiving antenna, its primary purpose is to convert the field strength in microvolts per meter to voltage across the input terminals of the television receiver, uhf or vhf as the case may be. How well does it do this? The power gain of a receiving antenna is commonly stated in db with reference to a half-wave dipole. A good vhf antenna will have a power gain of about 3 db on channels 2 to 6 and 5 db on channels 7 to 13 with reference to a half-wave dipole. A good uhf antenna will have a power gain of about 8 db, also with reference to a half-wave dipole. However, the half-wave dipole antenna is a better device at vhf than at uhf considering its important characteristic of converting field strength in microvolts (μv) per meter into voltage in μv across the matched impedance of the television receiver input terminals. For a given field strength, the developed voltage is directly proportional to the antenna lambda factor $5.58\sqrt{Z_o}/F_{mc}$; thus, it can readily be seen that this factor is inversely proportional to the frequency. This imposes a heavy handicap on uhf, as a few simple calculations will show. In Table VI are the lambda factors in db for a few important frequencies.

To summarize, assuming the antenna power gains previously mentioned and taking only the lambda factors and antenna gains shown in Table VI into consideration, there is a net gain of 6 db, —1.1 db and —9.0 db for channels 4, 10, and 39, respectively. This is quite a substantial handicap for the uhf receiver.

The most important considerations with respect to transmission lines are transmission line loss and voltage standing-wave ratio. The factor of greatest importance to the uhf–vhf problem is transmission line loss. The flat, 300-ohm ribbon type transmission line commonly used for vhf has a loss of 1 to 2 db per hundred feet. The oval shaped foam polyethylene transmission line frequently used for uhf has a loss of 3.7 db and 5 db per hundred feet at the low-frequency and high-frequency ends of the bands, respectively. The length of the average transmission line installation is about 70 feet, which means a loss of 2.6 db to 3.5 db at the low- and high-frequency ends of the band, respectively. If the same transmission line length is assumed for a vhf installation, the average loss from this source for vhf is 0.7 to 1.4 db. These figures are shown in Table VI, column 5.

Table VI. Average TV Receiving Antenna Characteristics

Channel	F_{mc}	Lambda Factor	Antenna Power Gain	Transmission Line Loss	Net Gain
		(db)	(db)	(db)	(db)
2	57	4.6			
4	69	3.0	3	0.7	5.3
6	85	1.0			
7	177	−5.2			
10	195	−6.1	5	1.4	−2.5
13	213	−6.9			
14	473	−13.8		2.6	
49	683	−17.0	8	3.0	−12.0
83	887	−19.3		3.5	

Table VII. Average TV Receiver Noise Factors

Channel	Noise Factor, db	
	Cascode RF Stage	Pentode RF Stage
2	6	8
3	6	8
4	6	8.5
5	6.5	8.5
6	6.5	9
7	8	13
8	8.5	13
9	8.5	13
10	8.5	13
11	8.5	13
12	8.5	13.5
13	9	13.5

Uhf Converters. Existing vhf television receivers can

be adapted to receive uhf signals by means of a converter which, in conjunction with the receiver, operates on a double superheterodyne principle and uses one of the vhf channels as the converter intermediate frequency.

An important characteristic of a uhf converter is its ability to amplify weak signals to a usable level with a good signal-to-noise ratio.

Most uhf converters employ a circuit consisting of a tuned preselector, an oscillator, a crystal mixer, an i-f amplifier, and a power supply. The over-all noise factor of such a converter in combination with a vhf receiver is determined mainly by the following three characteristics: (1) losses in the preselector and crystal mixer circuits, (2) noise factor of the converter i-f amplifier, and (3) noise factor of the vhf receiver.

The combined noise factor of the vhf receiver and converter i-f amplifier usually is found to be only slightly higher than the noise factor of the converter i-f amplifier alone, which may be assumed to be 6 to 7 db. This, combined with an assumed loss of about 10 db in the preselector and mixer circuits together, gives an over-all noise factor of about 16 to 17 db.

Other important converter characteristics are good oscillator stability, adequate selectivity, sufficient bandwidth and low oscillator radiation. A well-designed converter in current use can satisfy all of these requirements.

Converters may reasonably be considered as interim devices. Better results can be secured by using uhf receivers or combination uhf–vhf receivers.

Uhf and Vhf Receivers. In considering only the differences in performance of uhf and vhf receivers both for monochrome and color, many performance characteristics which otherwise are important may be disregarded. With respect to the problem at issue, namely, the contribution of receivers to the differences in coverage at uhf and vhf, it is justifiable to consider only the receiver noise factors since the signal-to-noise ratio on the receiver screen is the major limiting factor.

Present day vhf receivers employ a tuner with an r-f amplifier stage and exhibit average noise factors as shown in Table VII. The data in this table are averages of the measurements made on 30 typical receivers. No comparable data are yet available for uhf receivers.

Present day uhf receivers do not employ an r-f amplifier stage in the tuner. The reason for this is that there is not yet a suitable low-priced tube available. Noise factors for uhf tuners are, at this time, running from 12 to 15 db and are quite often as much as 18 db at the high-frequency end of the band. Proper selection of the crystal used in the mixer stage has an important effect on noise factors.

Table VI shows that the three factors previously considered (1) antenna gain, (2) antenna lambda factor, and (3) transmission line loss, penalized the uhf receiver to the extent of 17.3 db with respect to low-band vhf channels and 9.5 db with respect to high-band vhf channels, considering the performance at the center of these two bands. This situation becomes even more heavily weighted in favor of vhf when the receiver noise factors are taken into consideration. For example, an average vhf receiver has noise factors of 6 to 9 db. An average uhf receiver has noise factors from 12 to 15 db over the band. This means about 6 or 7 db more loss has to be added to the uhf net gain figures shown in Table VI for uhf receivers, leaving the over-all advantage, as far as receiving equipment is concerned, about 15 to 25 db in favor of vhf.

Fig. 12. Uhf receiving antenna—bent triangular dipole with corner reflector.

The relative cost of a uhf–vhf receiver as compared with a vhf receiver is of considerable interest. Based on information obtained from some of the larger manufacturers, the cost differential at the retail level is between $30-40 in favor of vhf. This figure represents the price difference to the consumer for a set equipped with both a vhf and a uhf tuner as compared with the same set equipped only for vhf reception.

The industry is continuing with a program to develop improved circuits, receiving tubes, antennas and over-all tuner designs for ultimate consumer use at uhf. Developments in receiving tubes for use in r-f amplifiers are being pressed vigorously since a low-cost tube with sufficient gain and low noise factor should permit the development of an improved uhf tuner. Present tubes with a sufficiently high degree of performance in the uhf band are high in cost and the few db reduction in noise factor which their use makes possible is not felt sufficient to justify the large increase in cost.

However, it does not seem feasible at this time entirely to close the gap in performance between uhf and vhf by receiver improvements alone. Lower loss transmission lines and higher gain antennas, if feasible, could materially ease the burden on the receiver design engineer.

TASO Panel 2 has set itself the task of collecting factual engineering data covering all important performance characteristics of present day uhf and vhf receiving equipment, antennas, and transmission lines. By this means Panel 2 also hopes to help the FCC in its studies of frequency allocation problems.

Data Transmission Testing Set

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A transmission testing set for high-speed data circuits is described. It is an electronic, transistorized device for laboratory use in the development of binary data transmission systems.

UNTIL RECENT YEARS the transmission of data in binary form was confined almost exclusively to telegraphic or similar low-speed communication systems. Transmission speed was limited by the rate of operation of printing telegraph or other terminal equipment. Distortion-measuring devices for determining the efficiency of synchronous or start–stop telegraph transmission circuits or equipment were well known to the art.[1,2] The recent introduction of integrated data-processing systems and computer centers requires the transmission of voluminous information in binary form and at high speeds. To develop circuits and equipment to handle these data intelligently first required the development of a transmission measuring tool capable of operation at the high speeds involved. It is the purpose of this article to describe an all-electronic transistorized testing set which will measure bias distortion, characteristic distortion, and peak fortuitous distortion at transmission speeds from 200 to 1,400 bits per second (bps).

BASIC PRINCIPLES

DISTORTION in binary pulse transmission may be defined as the deviation in length or relative time relationship of the received pulses from the length and time relationship of their transmission. A signal is defined as unbiased when the unit marking and spacing pulses are of the same length or time duration. Bias distortion usually results from improper adjustment of terminal or circuit equipment. A means for measuring this type of distortion should be included in a data transmission testing set.

Distortion which is caused by electrical or magnetic characteristics of the equipment or circuit under test is defined as characteristic distortion. It is the amount by which a given pulse is lengthened, shortened, or displaced as the result of the presence or absence of neighboring pulses and is caused by "memory" effects in the transmission path. More exactly, the maximum amount by which the space-to-mark and mark-to-space transitions of a selected pulse are shifted from their ideal locations by the presence or absence of neighboring pulses is a measure of the characteristic distortion. A device to measure characteristic distortion might then consist of a pulse-pattern generator for sending various combinations of marking and spacing pulses, a circuit for selecting one of the received pulses for examination, and a circuit for comparing the distorted received pulse with the undistorted transmitted pulse to indicate the amount of distortion. The characteristic distortion would be taken as the largest value indicated for all possible combinations of pulses from the pattern generator.

Fortuitous distortion is that displacement of signal transitions resulting from extraneous electrical interference in the transmission circuit. This interference is statistical in nature and has a random relation to the testing signals. The "instantaneous" distortion caused by fortuitous interference will vary widely although the "average" effect on a repeated pulse will integrate to zero. It is conventional to measure fortuitous distortion as the largest transition displacement encountered in a given period of time. The measurement of fortuitous distortion should not be influenced by the characteristic distortion of the circuit under test. A device to measure fortuitous distortion might then consist of a pattern generator for sending alternate marking and spacing pulses of equal length, a circuit for selecting one of the pulses for examination, and a peak-reading instrument for measuring the largest transition displacement during the period of observation.

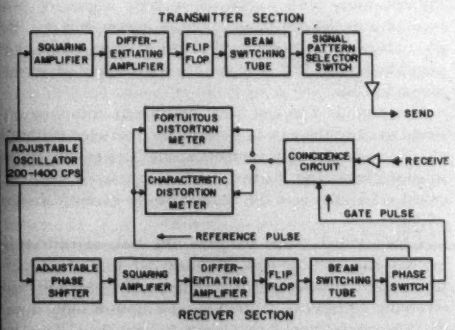

Fig. 1. Data transmission testing set, block diagram.

DESCRIPTION

IN CONTRAST TO TELEGRAPH CODES, data codes have not yet been standardized as to transmission speeds or num-

Full text of paper 58-172, presented at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Recommended for publication by the AIEE Telegraph Systems Committee. Scheduled for publication in AIEE *Communication and Electronics*, 1958.

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ber of code elements per character. For the design of a testing set a code of 10 elements and speeds from 200 to 1,400 bps was selected arbitrarily.

A block diagram of the testing set is shown in Fig. 1. It is completely transistorized except for two magnetron beam switching tubes and a subminiature electrometer tube. Both transmitter and receiver sections are controlled by the output of a 200- to 1,400-cycle sine-wave oscillator, adjustable in steps of 200 cycles. The oscillator frequency enters the transmitter section through a squaring amplifier. The square wave from this amplifier is then differentiated and the resultant pulses used to trigger a standard bistable flip-flop stage. Because the flip-flop reverses once per cycle of the applied frequency, its output is a highly symmetrical or unbiased square wave; i.e., the time durations of the negative and positive loops are equal. Two appropriately phased outputs from the flip-flop drive the odd and the even grids, respectively, of a 10-position beam-switching tube to advance the beam one position for each reversal of the flip-flop. A 10-position signal pattern selector switch associated with the beam-switching tube permits any one of ten signal patterns to be selected for transmission at a bit rate equal to the oscillator frequency in cycles per second.

The adjustable oscillator also operates a second beam-switching tube in the receiver portion of the test set so that both tubes run at exactly the same speed. The drive circuit for the receiver tube includes a continuously adjustable phase-shift network of 360-degree range. This network, in conjunction with a phase switch associated with the beam switching tube, permits a gate pulse and a reference pulse to be obtained once per revolution which can be placed in any desired time relationship with the transmitter signal pattern. These pulses have precisely the same length as the transmitter pulses. The gate pulse selects the leading or trailing portion of a given signal pulse to be measured by means of the coincidence circuit. The output of the coincidence circuit is applied to the characteristic distortion meter circuit where it is compared with the reference pulse for characteristic or bias distortion measurements. To measure peak fortuitous distortion, the output of the coincidence circuit is applied to the fortuitous distortion meter circuit.

Ten signal patterns each consisting of 10 bits are available for transmission as indicated in Fig. 2. The polarity of transmission can be as shown or reversed as desired. After transmission through the circuit or the equipment under test, pulse number 9 is normally used for characteristic distortion analysis. The signal patterns have been selected to include combinations producing the maximum distortion of the number 9 pulse that could occur with normal random-message traffic.

Bias and Characteristic Distortion Measurement. A circuit which has been designed for selection of leading or trailing portions of a received signal pulse for bias or characteristic distortion measurement is shown in Fig. 3. After transmission over the system under test,

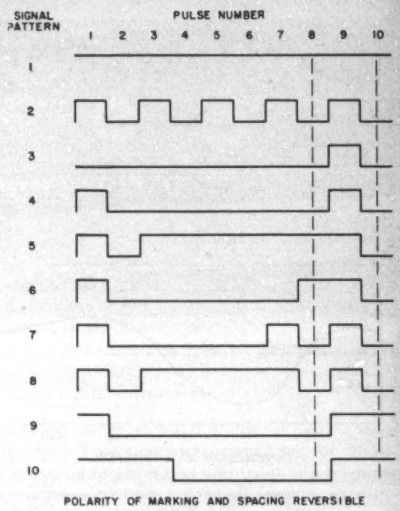

Fig. 2. Signal patterns available from transmitter.

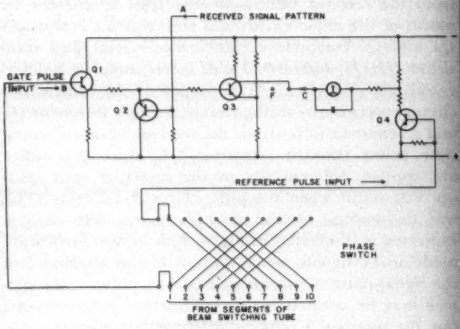

Fig. 3. Bias and characteristic distortion measuring circuit.

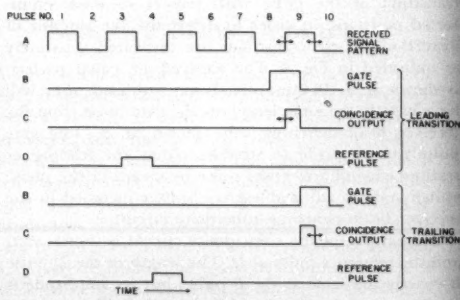

Fig. 4. Theory of bias and characteristic distortion measurements.

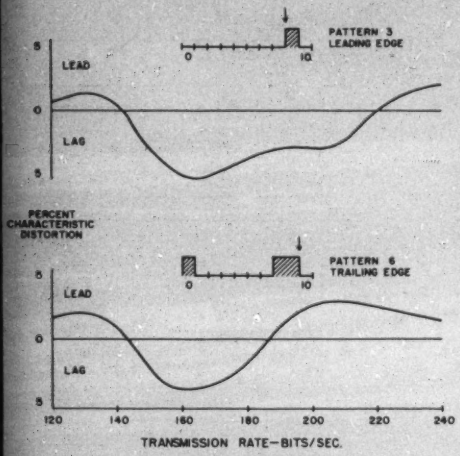

Fig. 5. Typical characteristic distortion curves.

the signals enter a coincidence circuit at *A*. A gate pulse from the receiver beam-switching tube is selected by means of the phase switch and enters at *B*. Transistors *Q1* and *Q2* comprise a coincidence circuit and transistors *Q3*, *Q4*, and 50-0-50 scale meter comprise a differential metering circuit. The output of the coincidence circuit enters the metering circuit through transistor *Q3* and a reference pulse from the receiver beam-switching tube enters through transistor *Q4*. Since the pulses are applied differentially to the meter, a zero reading will result when the pulses have equal areas. The way the amount of bias or characteristic distortion is indicated is illustrated in Fig. 4. Bias measurements are made on a-c signals, signal pattern 2, and position 2 of the signal pattern selector switch. Any pulse of the pattern may be selected for bias distortion measurements but the number 9 pulse is used for characteristic distortion measurements. It is necessary to measure the displacement of the leading transition and the trailing transition of the pulse with respect to their undistorted positions, in order to determine the amount of distortion. These transitions are measured separately as indicated in Fig. 4. The received a-c signal pattern is shown at *A*. If these signals are unbiased, they will have exactly the same length as the gate pulse from the receiver beam-switching tube shown at *B*. The gate pulse can be made to straddle either the leading or trailing edge of a received pulse by means of the phase switch and the adjustable phase shifter included in the receiver beam-switching tube drive circuit.

The output of the coincidence circuit is shown at *C* and the reference pulse at *D*. The length of the *D* pulse is exactly the same as the *B* pulse, but its amplitude is made to be precisely one half the amplitude of the *C* pulse. By properly adjusting the phase of gate pulse *B*, the *C* pulse for the leading transition of the number 9 signal pulse can be made exactly the same length as the *C* pulse for the trailing transition of the number 9 pulse so that both *C* pulses have the same length and area. If the signals are unbiased, then both *C* pulses are also equal in area to reference pulse *D*. Since the *D* pulse and a *C* pulse are applied alternately and differentially to the zero center d-c meter, a zero reading of the meter will result. If the received signals at *A* are biased, the length of the *C* pulses for the leading and trailing edges will still be equal. However, the *C* pulses will be greater or smaller in area than the *D* pulse, depending on whether the bias is marking or spacing, and the differential meter will indicate directly the direction and magnitude of the bias in per cent of the duration of an undistorted pulse. An integrating condenser in the differential meter circuit produces a steady meter reading by eliminating the effects of fortuitous interference. A bias measurement is made by alternately switching between two adjacent positions of the phase switch, to select alternately the leading and trailing transitions, and by simultaneously adjusting the phase shift network for the same meter reading.

Before characteristic distortion measurements can be made, all bias should be removed from the signals to be measured using the above procedure to indicate the unbiased condition. As described, the characteristic distortion is measured by selecting signal pulse number 9, and observing the displacement of the leading and trailing transitions for the various signal patterns. The displacements are measured relative to the location of the leading and trailing transitions for signal pattern 2 (a-c).

Pulse 9 is selected for measurement by transmitting signal pattern 3, consisting of a single pulse in position 9. If gate pulse *B*, Fig. 4, is coincident with any other pulse position than number 9, the differential meter will read −50% distortion since only reference pulse *D* is applied to the meter circuit. The leading edge of pulse number 9 is located by rotating the phase switch in a clockwise direction until the meter reads other than −50%. The meter reading is a direct measurement of the leading edge displacement in percentage of the length of an undistorted pulse. This reading can be converted to time, if desired, since the pulse transmission rate

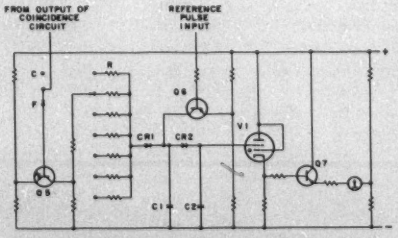

Fig. 6. Peak fortuitous distortion measuring circuit.

is accurately known. If the leading edge is not affected by characteristic distortion, it will have the same location as for pattern 2 (a-c), and the meter will read zero. The displacement of the trailing edge can similarly be measured by rotating the phase switch to the next adjacent clockwise position. In such fashion, the displacement of the transitions are measured for signal patterns 3 through 10. The amount of characteristic distortion for the particular transmission speed is taken as the largest meter reading of the series. To delineate the characteristic distortion characteristic completely, measurements must be made for a range of speeds. Typical curves of distortion vs speed measured in a medium-speed data channel are given in Fig. 5. The effect of speed on the leading transition of the number 9 pulse for pattern 3, and the trailing transition of the number 9 pulse for pattern 6 are clearly shown.

Fortuitous Distortion Measurement. Fortuitous distortion displaces the leading and trailing transitions of a signal pulse in a random manner. It is customary to measure the greatest displacement occurring in a specified time interval and define this value as the peak fortuitous distortion of the circuit or equipment under test. Fortuitous distortion measurements are made on a-c signals, signal pattern 2, to eliminate any meter deflection caused by characteristic distortion. The signals must also be checked for bias and corrected if necessary. The circuit used to measure peak fortuitous distortion is illustrated in Fig. 6. Pulses from the coincidence circuit are applied to transistor *Q5*, and the reference pulses from the receiver beam switching tube to transistor *Q6*. The fixed-amplitude pulse from the coincidence circuit is applied to integrating capacitor *C1* through a resistor and diode *CR1*. Capacitor *C1* charges to a voltage directly proportional to the time duration of the pulse and is bound by the action of diode *CR1*. Capacitor *C2*, which is small compared to *C1*, charges through diode *CR2* to the same value as *C1*. The reference pulse from the receiver switching tube discharges *C1* by driving *Q6* to conduction, leaving a bound charge on *C2*. If the next pulse from the coincidence circuit is longer than the preceding pulse due to fortuitous distortion, *C1* will charge to a higher value, as will capacitor *C2*. In this manner, a charge is accumulated on *C2*, which is proportional to the largest displacement of the pulse transition. The voltage of *C2*, resulting from its accumulated charge, is measured by electrometer tube *V1*. The plate current of *V1* is, thus, a measure of the widest pulse occurring during the measuring period. This current is amplified by transistor *Q7* and displayed on a 0-to-40 scale meter calibrated to indicate distortion in per cent of the length of an undistorted pulse. Both the leading and trailing transitions are measured, the larger of the two being the peak fortuitous distortion for the particular speed of transmission. Calibration is maintained for different speeds of transmission by the automatic selection of the proper charging resistor *R* for a given signaling speed.

Fig. 7. Data transmission testing set, front view.

RESULTS

A PROTOTYPE MODEL of the transmission testing set is shown in Fig. 7. This model was constructed for laboratory use only and requires that both ends of a transmission circuit be available in order to permit measurements to be performed. Models for field use would require a highly stable frequency source to permit accurate synchronization and phasing of units at the ends of an intervening circuit being tested. The prototype has been in use for several months and has proved of valuable assistance in the development of data transmission circuits and equipment. It has been of particular use in studies concerning the effect of envelope delay distortion on high-speed data transmission.

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Sensitive Mine Detector

A lightweight transistorized land mine detector with greatly increased sensitivity and other advantages over detectors currently in use has been developed by Texas Instruments, Inc., for the U.S. Army.

Because it is transistorized, the new detector has a much longer battery life and enhanced reliability under rugged field conditions of use, it was pointed out. Use of transistors also has permitted miniaturization of the device to the point where all parts except the antenna can be carried under the operator's clothing. This is considered of special importance where the detector is to be used in arctic regions. The detector also is fungus-proof for advantageous use in the tropics.

Corona-Level Scanning of High-Voltage Power Cables

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AN APPARATUS has been developed for the purpose of detecting and locating the presence of small voids or air pockets in rubber or plastic cable insulation. This is especially important in cases where the operating voltage of the cable is high enough to ionize the gas in these void spaces, because continued ionization may eventually erode or burn its way through the insulation, and result in cable failure.

Although ionization or corona may be detected by testing the entire length in which the cable is manufactured (full-reel corona testing), probing or scanning the cable foot by foot has advantages of sensitivity and exact location of even the smallest evidence of defect in the insulation. Therefore, use of the latter method permits the elimination of the defect and, consequently, gives the closest approach to a "perfect cable."

The more obvious devices for making this test, such as a metal sleeve or water tank through which the cable is drawn, are only partially effective because the air external to the cable becomes ionized. In the wax tank method, patented by H. B. Slade in 1945, ionization of air external to the cable is prevented. However, a liquid dielectric apparatus has several disadvantages and limitations.

The improved apparatus consists of a long pipe made of insulating material, with a metal tank at each end. The pipe is filled with purified water maintained at a resistivity of the order of one megohm per cubic centimeter Inside the pipe, at the center of its length, is a metal ring connected through the pipe wall to a high-voltage transformer. The metal ring is also connected to corona-detecting equipment by way of a high-voltage coupling capacitor.

The insulated unshielded cable, with its conductor grounded, is passed through the water-filled pipe. The encircling water is at high voltage at the pipe center, and the voltage falls off linearly toward the grounded tank at each end. Every point on the cable is, therefore, exposed to an increasing stress as it passes through the pipe, until it reaches the maximum at the pipe center. Thereafter, the stress on the cable reduces until it becomes zero at the point where the cable leaves the pipe. This device insures that there is no corona at the ends of the cable section under test, because at each end tank both the cable conductor and the water surrounding the cable are at ground potential. If (1) a small void or gas bubble, fragment of porous material, or possibly a speck of metal, exists within the insulating wall, (2) the insulation is not applied snugly to the inner conducting member, or (3) the semiconducting tape or the conductor is damaged, the resulting gas pocket will become ionized when it reaches a point in the water tube at which the voltage is sufficiently high. This event is indicated by the corona detector. The presence of any ionizable defect, therefore, can be identified positively. The signal from the corona detector may be applied to a paper-tape recorder.

Finding the exact location of a fault is accomplished by adjusting the cable in the pipe until a maximum signal is obtained on the recorder. The fault is now at the pipe center, and the cable is marked at that point when it leaves the tank. Corrective measures can be applied at a later time.

When a defect in a cable can be identified and examined, it is frequently possible to assign a cause and prevent repetition of the occurrence, thereby permitting a tightening up of factory process control.

The distilled water in the pipe is maintained in a condition of low conductivity by circulating it through a bed of deionizing resin. This permits continuous operation of the equipment without overload.

An analysis has been made of the electrical stress which exists in a void located within the wall of a 15-kv rubber-insulated cable when the cable is energized at its operating voltage. The stress is compared to the stress necessary to ionize the air in the void, and possibly initiate breakdown in service. If the radial thickness of the void is less than 5 mils, it is unlikely that it will ionize in service when the normal voltage is applied. A 50-mil void is likely to ionize at operating voltage, especially if located near the conductor. The dimensions of the conductor and dielectric constant of the insulation have an important bearing on the stress conditions within a void.

A number of experimenters have shown that the voltage necessary to initiate corona in an air film bounded on one or both sides by a wall of dielectric has the same value as for sparking potential in a uniform field, between metal electrodes.

The height of the corona pulse under given conditions of voltage, and for a specific void, varies inversely as the capacitance of the section of cable under test. Greater sensitivity, therefore, is available when short lengths of cable are being tested than when a full reel length is in the circuit.

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Digest of paper 57-732, recommended by the AIEE Insulated Conductors Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Published in AIEE *Power Apparatus and Systems*, Dec. 1957, pp. 999-1009.

F. H. Gooding and H. B. Slade are with The Okonite Company, Passaic, N. J.

Nation-Wide Switching of Intertoll Trunks

O. F. WALLMAN
MEMBER AIEE

THE NATION-WIDE SWITCHING of intertoll trunks by switching machines instead of manual interconnection at toll switchboards requires many new and improved transmission circuits and equipment arrangements associated with the new switching systems at selected major switching centers. The assurance of satisfactory transmission performance on a high percentage of interconnections requires the establishment of a fundamental switching plan.

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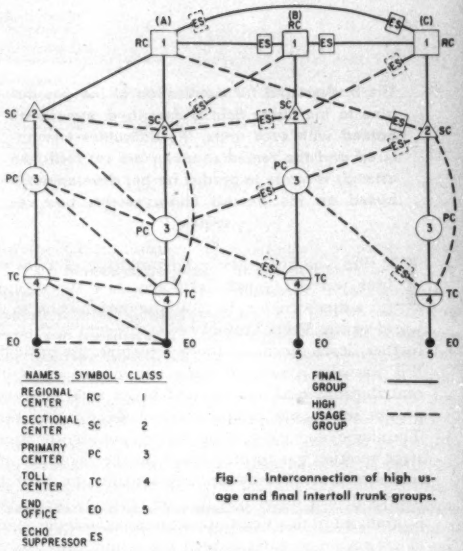

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5. Singing
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Some of these factors are controlled by design of the individual transmission systems and others are controlled by the arrangement and design of the individual switching systems.

Switching systems of the 4- and 2-wire type are employed in the nation-wide switching layout. Their selection for a particular location is generally based on economic studies. The economics of the 4-wire switching system favors its use in the larger switching offices. These systems are desirable where they can be economically justified, because they are void of singing and echo paths. In 2-wire switching systems, it is important to design and arrange the individual components of the switching systems so as to provide high return losses in the frequency ranges, an important consideration from a singing and echo standpoint. In addition, sufficient tests must be made to determine that transmission performance will be satisfactory on switched connections.

About half of the ultimate number of switching systems contemplated in the plan are now installed. Each year's additions add to the possible number of interconnections that can be made. This also increases the complexity of the operating and maintenance problems. To assure satisfactory performance of the over-all switching plan, tests are required on individual trunk circuits and transmission circuits in the switching offices.

The extensive use of carrier facilities with their high velocity of propagation aids materially in obtaining the low over-all transmission losses required for the successful operation of the plan. It is still necessary, however, to employ echo suppressors to control the detrimental effects of echoes on the long interregional connections. Echo suppressors are also required to provide interconnection with the Canadian switching plan and connections involving the new transatlantic and transpacific submarine cables.

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Corona-Level Scanning of High-Voltage Power Cables

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AN APPARATUS has been developed for the purpose of detecting and locating the presence of small voids or air pockets in rubber or plastic cable insulation. This is especially important in cases where the operating voltage of the cable is high enough to ionize the gas in these void spaces, because continued ionization may eventually erode or burn its way through the insulation, and result in cable failure.

Although ionization or corona may be detected by testing the entire length in which the cable is manufactured (full-reel corona testing), probing or scanning the cable foot by foot has advantages of sensitivity and exact location of even the smallest evidence of defect in the insulation. Therefore, use of the latter method permits the elimination of the defect and, consequently, gives the closest approach to a "perfect cable."

The more obvious devices for making this test, such as a metal sleeve or water tank through which the cable is drawn, are only partially effective because the air external to the cable becomes ionized. In the wax tank method, patented by H. B. Slade in 1945, ionization of air external to the cable is prevented. However, a liquid dielectric apparatus has several disadvantages and limitations.

The improved apparatus consists of a long pipe made of insulating material, with a metal tank at each end. The pipe is filled with purified water maintained at a resistivity of the order of one megohm per cubic centimeter. Inside the pipe, at the center of its length, is a metal ring connected through the pipe wall to a high-voltage transformer. The metal ring is also connected to corona-detecting equipment by way of a high-voltage coupling capacitor.

The insulated unshielded cable, with its conductor grounded, is passed through the water-filled pipe. The encircling water is at high voltage at the pipe center, and the voltage falls off linearly toward the grounded tank at each end. Every point on the cable is, therefore, exposed to an increasing stress as it passes through the pipe, until it reaches the maximum at the pipe center. Thereafter, the stress on the cable reduces until it becomes zero at the point where the cable leaves the pipe. This device insures that there is no corona at the ends of the cable section under test, because at each end tank both the cable conductor and the water surrounding the cable are at ground potential. If (1) a small void or gas bubble, fragment of porous material, or possibly a speck of metal, exists within the insulating wall, (2) the insulation is not applied snugly to the inner conducting member, or (3) the semiconducting tape or the conductor is damaged, the resulting gas pocket will become ionized when it reaches a point in the water tube at which the voltage is sufficiently high. This event is indicated by the corona detector. The presence of any ionizable defect, therefore, can be identified positively. The signal from the corona detector may be applied to a paper-tape recorder.

Finding the exact location of a fault is accomplished by adjusting the cable in the pipe until a maximum signal is obtained on the recorder. The fault is now at the pipe center, and the cable is marked at that point when it leaves the tank. Corrective measures can be applied at a later time.

When a defect in a cable can be identified and examined, it is frequently possible to assign a cause and prevent repetition of the occurrence, thereby permitting a tightening up of factory process control.

The distilled water in the pipe is maintained in a condition of low conductivity by circulating it through a bed of deionizing resin. This permits continuous operation of the equipment without overload.

An analysis has been made of the electrical stress which exists in a void located within the wall of a 15-kv rubber-insulated cable when the cable is energized at its operating voltage. The stress is compared to the stress necessary to ionize the air in the void, and possibly initiate breakdown in service. If the radial thickness of the void is less than 5 mils, it is unlikely that it will ionize in service when the normal voltage is applied. A 50-mil void is likely to ionize at operating voltage, especially if located near the conductor. The dimensions of the conductor and dielectric constant of the insulation have an important bearing on the stress conditions within a void.

A number of experimenters have shown that the voltage necessary to initiate corona in an air film bounded on one or both sides by a wall of dielectric has the same value as for sparking potential in a uniform field, between metal electrodes.

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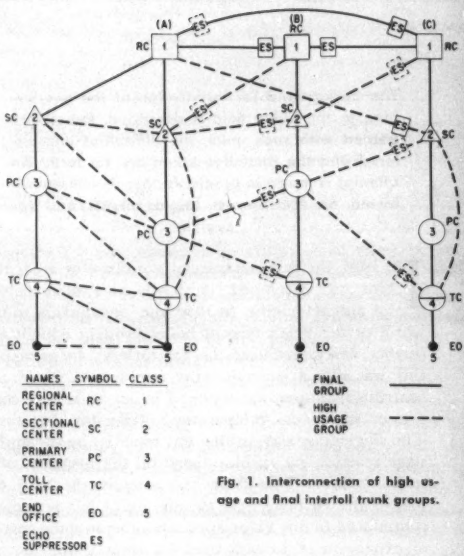

Fig. 1. Interconnection of high usage and final intertoll trunk groups.

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Large Gas Turbines for Central Station Application

Z. S. STYS

The background for application of the gas turbine to the utility field is described. Experience gained with such units, the difficulties encountered and the remedies taken are set forth. An attempt is made to predict further developments based on the newest improvements and research.

IN 1926, the first commercial prototype of a gas turbine was developed specifically as a supercharger for a diesel engine. In 1930, the introduction to the world of the Velox type of boiler brought with it the further development of the gas turbine. In principle, this was also a supercharging application where the centrifugal blower was replaced by an axial flow compressor which was comparatively large for that time. The single-stage gas turbine was replaced by the multistage reaction gas turbine based on the principle of a steam turbine. This setup was actually the basis for today's Brown Boveri gas turbine unit.[1] No net power is produced in this Velox application because the energy of expansion of gases is used for compressing the air supplied to the highly pressurized boiler chamber.

A further step in the development of the gas turbine was achieved by applying this type of machine to the Houdry oil cracking process. The heat balance of this application made it possible to generate some 600 kw. However, the world's first gas turbine which had all the components that today's modern units possess, was built for the City of Neuchatel, Switzerland, in 1939, to generate 4,000-kw electrical output.

POWER GENERATION

IN POWER GENERATION, there are but two basic problems; namely, the base-load and the peak-load generation.

The base-load problem was solved by most of the utilities merely by adding new capacity. The handling of the short duration peak loads—which in some systems occur only a few hundred hours annually and are sometimes as large as a couple of hundred thousand kw—often creates a real problem. Storage-type hydroelectric plants or old steam units are mostly used for this kind of operation. The generally known factors which a peaking machine must comply with are: quick starting, low initial cost, minimum maintenance, simplicity of operation, and low operation cost.

The gas turbine, with its inherent simplicity, is very suitable for quick starting compared only with starting time required by a Diesel engine. Fig. 1 presents the starting diagram of the two-shaft gas turbine based on the actual test performed in the factory where the availability of the full power, from cold start, is reached in a matter of seven minutes.

Again because of the inherent simplicity of a gas turbine, the cost of the equipment itself, is much less than that of a conventional steam power plant of like capacity. Additional savings are made possible by the fact that the gas turbine requires a smaller building to house it and does not require special accessories like a water treatment installation, condensing plant, etc. Savings are likewise effected in maintenance because there are no accessories to maintain.

As far as the supervising and operating expenses are concerned, it compares extremely favorably with the steam plant. Its simplicity makes it immediately suitable for fully automatic or even remote-controlled operation.

As far as the base-load operation is concerned, fuel costs materially influence the choice of the type of gas turbine. Higher fuel costs tend to indicate the selection of the regenerative type of turbine as its higher efficiency fully justifies the higher initial cost of such unit. This picture changes where very cheap fuel is available as the initial cost of construction of the plant plays an important role in selection of the equipment. In such cases, the nonregenerative type of gas turbine is fully justified for base-load operation.

FIRST APPLICATION IN THE POWER FIELD

BASED ON THE FOREGOING CONSIDERATION, several utilities all over the world decided to place gas turbines in their systems on an experimental basis. In addition to the previously mentioned Neuchatel unit, which operates in emergencies and for demonstration purposes, Table 1 gives the commissioning dates and the total operating hours of the first units.

Between the years 1939 and 1954 a total of 34 units were ordered with a total output of 228,000 kw. The major units were the following:

Santa Rosa, Lima, Peru—A 10,000-kw unit, with heat exchanger, was installed in October 1949 and is operating today, carry the peak-load supply for the City of Lima.

Essentially full text of paper 58-164, recommended by the AIEE Power Generation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

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Pertigalete I and II, a cement mill in Venezuela ordered two units of 1,650-kw output to supply power for the mill. These units have performed highly satisfactorily on a Bunker *C* fuel (with vanadium pentoxide) diluted 3 to 2 with light oil.

Pertigalete III and IV. Two units of 5,000-kw output were installed in 1953 and 1955.

Beznau[2]. The real prototypes of the large, modern gas turbine for central station use were the two units of 13,000- and 27,000-kw output, shown in Fig. 2. They were put in operation in 1948 and 1949 and supply peak power for the hydro-system.

The availability of different fuels at different sites necessitated the different burner construction which led to the design of the units burning blast furnace gas like those at Dudelange, Luxemburg, and others. It is possible to burn two fuels simultaneously or switch from one to the other by applying a special type of burner.

Table I.

Installation	Output kw	Operation: Commissioning Date	Operation: Until	Hours in Operation
Santa Rosa, Lima, Peru	10,000	Oct 1949	Oct 1956	14,535
Pertigalete I, Venezuela	1,650	Nov 1949	May 1956	27,547
Pertigalete II, Venezuela	1,650	Oct 1949	May 1956	26,436
Pertigalete III, Venezuela	5,000	Jan 1953	May 1956	19,702
Pertigalete IV, Venezuela	5,000	Apr 1955	May 1946	7,727
Beznau I, Switzerland	13,000	Jan 1948	Apr 1956	14,078
Beznau II, Switzerland	27,000	Jan 1949	Apr 1956	11,630
Dudelange, Luxemburg	5,400	Mar 1951	Mar 1956	31,937

DIFFICULTIES WITH FIRST UNITS

CERTAIN DIFFICULTIES[3] developed after a number of operating hours involving material and design matters. Research provided appropriate remedies to overcome them.

Historically, the first major difficulty was the damaged refractory liners of the combustion chamber. The adoption of the totally metallic liners with cooling fins on the back, thus assuring proper cooling effect, eliminated this trouble.

Several gas turbines have heat exchangers to recover a portion of the heat (about 75%) available in the exhaust gases. Accumulation of soot in the heat exchanger caused fire immediately after the stoppage of the machine. This difficulty was solved by installing soot blowers which go into operation periodically.

Fouling of the compressor blades and corrosion of the intermediate coolers were recognized as a result of the following set of occurrences. While burning heavy crudes with sulphur content, sulphur dioxide (SO_2) and sulphur trioxide (SO_3) are generated and, thus, present in the exhaust gases. The prevailing winds sometimes lead these gases or a portion of them, back into the suction of the compressor and subsequently to the air cooler where the water vapor available in the air is condensed. The water together with this sulphur dioxide formed sulphuric acid which corroded the tubes of the air cooler. Copper sulphate was created which was subsequently carried over to the next compressor and deposited on the blades, thus fouling them. By changing the position of the air intake, this problem was solved. It only shows how careful one has to be in the study of the atmospheric conditions at the site of the gas turbine.

The blade ruptures in the high temperature zone led to redesign of the blade foot. Also, as a result of long-range tests performed in the laboratory, materials of better temperature resistance were adopted.

The large quantities of intake air require long blades of the *LP* compressor. The vibration of these blades led to their rupture mostly in the first two rows of the first stage *LP* axial flow compressor. Extensive study resulted in the development of a method of calculating and also measuring in stroboscopic light the frequency of the vibration, thus creating a base for the suitable choice of the blade profile which overcame this trouble.

The well-known difficulty experienced also by the Diesel engine builders while burning heavy Bunker *C* oils especially contaminated with vanadium pentoxide or vanadium metal was also present while operating a gas turbine with this type of fuel. The ashes which resulted from the burning of this oil created deposits especially on the first two rows of blades, causing a drop in output and efficiency. These ashes also produce sometimes (in the presence of vanadium especially) catalytic action of decomposition of the blading material. A set of injection nozzles was installed and periodic washing of the machine during occasional

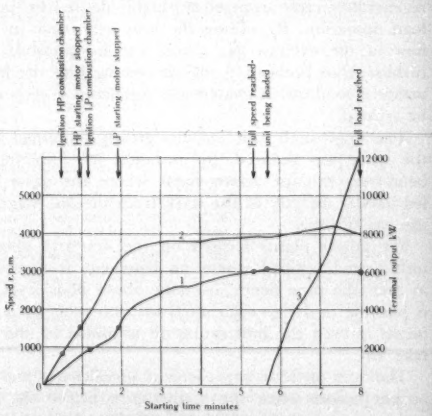


Fig. 1. Starting diagram, two shaft gas turbine.

Courtesy Brown Boveri Corp.

Fig. 2. A 40,000-kw power plant, Beznau, Switzerland.

stoppage of operation was adopted. Such washing only takes about half an hour after which the unit is ready for immediate operation practically with the output and efficiency of a new machine. This procedure was adopted for practically every machine burning heavy crudes.

IMPROVEMENTS—ADVANCEMENT

As more and more operating experience was gained from sets in current use, it was logical that new ideas would also be incorporated in the design of future sets.

First of all, the double-flow low pressure shaft arrangement as in the large Beznau unit was abandoned. By opening the angle of the blades and increasing the air quantity through the machines, the output was materially increased; i.e., from the smallest size of Beznau unit (13,000 kw), a size of 20,000/30,000 kw was developed. The diagram of this double-shaft simplified arrangement is presented in Fig. 3. This is a non-regenerative cycle arrangement highly desired for peak-load operation. By adding the heat exchanger in the flow of the exhaust gases from the low-pressure gas turbine, thus preheating the air coming into the high pressure combustion chamber, a regenerative cycle can be created.

The single-shaft unit was also greatly simplified and the space was reduced, for instance, by designing a bend-free, exhaust arrangement where the gases are led axially directly to the stack from the last stage of the gas turbine.

For power plants located on the desert, a special unit was developed where no basement is necessary as even the pipe bends are done above floor level. It is possible to design such units with no water requirements as even the lubricating oil is cooled by the intake air.

The very obvious improvement in efficiency and in output occurs when the temperature before the gas turbine is raised to a higher level. Fig. 4 shows how much gain can be achieved simply by raising the inlet temperature. The fact is, however, that the ferritic steel used thus far in the design of the gas turbines could be successfully used only up to the temperature range of about 1,100 F. The unknown long-range behavior of austenitic steel at the high temperatures provided the solution with application of ferritic steel by lowering artificially the temperature of the metal which would otherwise have gotten into contact with high temperature gases. Thus, the double casing was developed along with the cooling arrangement of the front part of the rotor including the first rows of blades. This is the way turbines for 1,200 F operation were built.

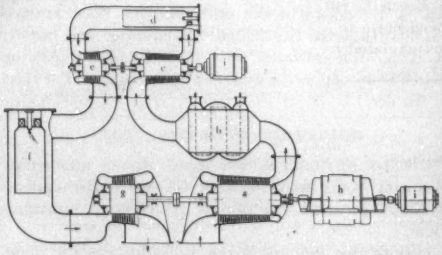


Fig. 3. Double shaft arrangement, large gas turbine.

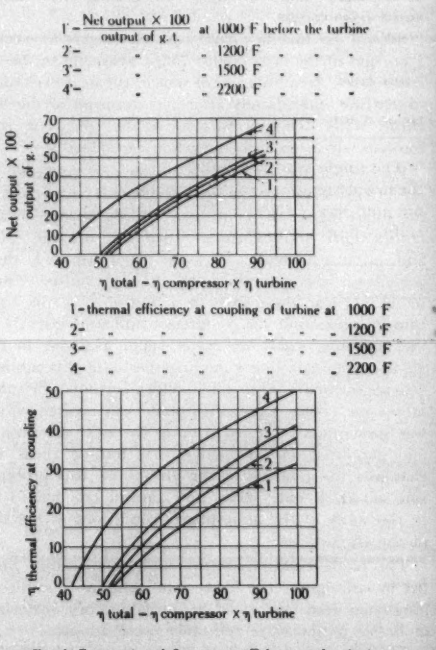

1 - Net output × 100 / output of g. t. at 1000 F before the turbine
2 - " " " 1200 F " " "
3 - " " " 1500 F " " "
4 - " " " 2200 F " " "
Net output × 100 / output of g. t.
70
60
50
40
30
20
10
0
40 50 60 70 80 90 100
η total = η compressor × η turbine
1 - thermal efficiency at coupling of turbine at 1000 F
2 - " " " " " " 1200 F
3 - " " " " " " 1500 F
4 - " " " " " " 2200 F
η thermal efficiency at coupling
50
40
30
20
10
0
40 50 60 70 80 90 100
η total = η compressor × η turbine

Fig. 4. Temperature influence on efficiency and output.

To achieve still higher temperatures which predict higher outputs and efficiencies leads again to the direction of lowering the actual metal temperature by using more complex cooling arrangements rather than using very extensive high-temperature steel alloys. These alloys have not been proved satisfactory for safe and trouble-free operation for periods acceptable in utility operation. The experience gained in jet engines was of little help inasmuch as the policy of exchanging the rotor of such an engine every 500 to 1,000 hours would obviously be entirely unacceptable in the central station operation.

OPERATING EXPERIENCE WITH MODERN UNITS

BASED ON THE SUGGESTED IDEAS, new gas turbines have been built and put in operation. Table II shows their accumulated operating time.

Table II.

Installation	Output kw	Operation		Hours in Operation
		Commissioning Date	Until	
Dhahran I, Saudi-Arabia	5,000	May 1954	July 1956	14,920
Dhahran II, Saudi-Arabia	5,000	Apr 1954	July 1956	15,466
Dhahran III, Saudi-Arabia	5,000	Dec 1954	July 1956	10,849
Dhahran IV, Saudi-Arabia	5,000	Nov 1955	July 1956	5,508
Tembi I, Iran	4,000	Aug 1955	Feb 1956	2,577
Vermilion, Canada	6,000	Oct 1954	May 1956	8,945
Jeddah I, Saudi-Arabia	6,000	June 1955	Aug 1956	5,915
Jeddah II, Saudi-Arabia	6,000	July 1956	Aug 1956	442
Livorno I, Italy	25,000	Feb 1956	Nov 1956	1,722
Livorno II, Italy	25,000	Oct 1956	Nov 1956	642

The single shaft gas turbine of 7,000-kw output of the new design was installed in Vermilion, Canada, and put into service in October 1954. After two years' operation, results were obtained as indicated in Table III.

Table III.

Time Interval	Nov 1954 to Nov 1956
Costs of parts exchanged	$ 310.50
Cost of labor	$1,178.30
Type of service	Peaking load
Average starts per day	2
Total number of starts	747
Total operating hours	10,990.5
Total generated output	59,081,400 kw-hr
Average load	5,375 kw
Daily peak: Winter	7,000–8,200 kw
Summer	5,400–7,000 kw
Duration peak	35 minutes
Rated load	6,200 kw
Fuel	Natural gas
Efficiency at 6,000 kw, 72 F	21.2% resulting in gas consumption of 18.34 cubic feet per kw-hr
Oil consumption	About 65 gallons
Unscheduled shutdowns	4
Reasons	(1) Failure Brown temperature indicator. (2) Failure mercury contactors. (3) Electrical trouble in outside grid. (4) Alarm in d-c supply.

As the first representative of the two-shaft modern gas turbines of large outputs, the so-called Livorno type is an example. The units were installed in the first modern plant of this type in Livorno, Italy. The first unit was put into service in February 1956 and the second in October 1956. Table IV gives the performance tests of these units, done on site.

Table IV.

	Output kw	Air Temperature (C)	Cooling Water Temperature (C)	Efficiency Per Cent
Set 1				
Measured value	25,097	17.07	19.29	24.315
Reading corrected for 15 C air suction temperature	26,008	15	15	24.636
Set 2				
Measured value	24,436	19.52	21.69	24.102
Reading corrected for 15 C air suction temperature	25,995	15	15	24.719

Figs. 5 and 6 show the Vermilion (Canada) and the Livorno (Italy) installations respectively.

Based on the experience with these two power plants, Table V shows the utilities that decided to use the gas turbines in their systems.

Table V.

Name of Installation	Output, kw	Year of Order
Oran, Algeria	11,000/12,000	1955
Oran, Algeria	11,000/12,000	1955
Rome, Italy	25,000	1955
Outerbacken, Sweden	27,500	1955
Caracas, Venezuela	20,000	1955
Riyadj, Saudi-Arabia	6,000	1955
Riyadj, Saudi-Arabia	6,000	1955
Riyadj, Saudi-Arabia	6,000	1955
Riyadj, Saudi-Arabia	6,000	1955
Haifa, Israel	10,000	1955
Haifa, Israel	10,000	1955
Edmonton, Canada	20,000/30,000	1955
Edmonton, Canada	20,000/30,000	1955
Elkpoint, Canada	9,000	1955
Joarcam, Canada	20,000/30,000	1955
Sturgeon Lake, Canada	6,200/10,000	1955
Kindersley, Canada	6,200/10,000	1956
Kindersley, Canada	6,200/10,000	1956
Lethbridge, Canada	6,000/10,000	1956
Vancouver I, Canada	23,000/27,000	1956
Vancouver II, Canada	23,000/27,000	1956
Vancouver III, Canada	23,000/27,000	1956
Vancouver IV, Canada	23,000/27,000	1956
Bahrain I	6,100	1956
Bahrain II	6,100	1956
Las Morochas I, Venezuela	20,000	1956
Las Morochas II, Venezuela	20,000	1957
Neusiedeln, Austria	13,900	1956
Edmonton, Canada	6,000/10,000	1956
Karachi I, Pakistan	5,700/6,700	1956
Karachi II, Pakistan	5,700/6,700	1956
Mayaguez I, Puerto Rico	20,000	1956
Mayaguez II, Puerto Rico	20,000	1956
Grangesberg, Sweden	27,500	1956
Riyadj, Saudi-Arabia	6,000	1957
Riyadj, Saudi-Arabia	6,000	1957
Bremen I, Germany	25,000	1957
Bremen II, Germany	25,000	1957
Berlin I, Germany	24,000/30,000	1957
Berlin II, Germany	24,000/30,000	1957
W. Germany Navy (NATO)	12 units (classified)	1956

The unit in Caracas which is now being installed, has a provision for entirely remote-controlled operation. The four units for Vancouver, Canada, will also be equipped for the same kind of operation.

Courtesy Brown Boveri Corp.

Fig. 5. A 7,000-kw gas turbine unit, Vermilion, Canada.

An experimental unit for 1,400 F operation was built and installed in St. Dizier, France. This unit of 7,000-kw rating is designed to burn light oil, but for later changeover to the heavy crude. In order to supervise constantly the temperature of the turbine rotor which was made from ferritic steel, the same as the casing of the gas turbine, 12 small channels were drilled in the rotor for thermocouples having their outlets at the rings arranged on one side of the shaft where the temperature was indicated and observed. Based on the performance of this unit, the customers shown in Table VI decided to go to units which will operate with 1,400 F gases.

Table VI.

Name of Installation	Output, kw	Year of Order
St. Dizier, France	6,080	1953
Shelton Iron, Great Britain	2,500	1954
Duisburg, Germany	5,820	1954
Rodange, Luxemburg	7,300	1955
La Chiers Longwy, France	7,300	1955
Haspe, Germany	14,000	1955
Dortmund, Germany	14,000	1955
Donawitz, Austria	14,000	1955
Rheinhausen, Germany	15,000	1957

Between 1955 and 1957, over 60 gas turbines were ordered for a total output of over 1 million kw.

It is worth while to mention a special application of such gas turbines which should also be interesting to a utility, namely a mobile power plant described in the author's American Society of Mechanical Engineers (ASME) paper[4] of April 1956. Three such units were built for Comision Federal de Electricidad in Mexico. The unit consists of two cars. One car is the actual gas turbine power plant and the other car houses the transformer, the different taps for different voltages, starting equipment, battery, small diesel, and other auxiliary equipment. It is very interesting that the comparison given in Table VII was made by a customer who was thus led to his decision to purchase gas turbine mobile power plant instead of steam or diesel.

Table VII.

Driving Machine	Cost of Complete Plant (Per Cent)	Fuel Cost per kw-hr (Per Cent)	Total Cost per kw (Per Cent)
Diesel	150	88	122
Steam Turbine	130	100	118
Gas Turbine	100	100	100

Such units can be built on any kind of vehicle, like Caterpillar tractor with trailer, standard truck and trailer, railroad flatcar, etc., for use effectively in emergencies.

The operating experience of the gas turbine was generally very satisfactory. Based on the calculation done with the units being longest in operation (namely, Beznau Power Plant), it is assumed that an operating cost of about $36,000 per year would apply to a gas turbine power plant whereas a similar size steam power plant would require about $100,000 in operating labor cost per year.

Insofar as maintenance is concerned, a periodic inspection of the combusion chamber is necessary to insure safety of operation. This can be done very easily by taking off the burner and lowering the operator through this large burner opening to inspect the liners of the combustion chamber during a stop period.

At the same time, the periodic inspection of the fuel nozzles can be performed to assure proper atomization of the fuel during combustion.

Depending on the kind of fuel, regular washing, by means of water injection is necessary. In the case of Bunker *C* oil, such a period of washing occurs between 300 and 400 hours. This period can even be extended to over 400 hours of continuous operation in some cases.

The scheduled cleanings of the fuel tanks as well as the regenerator tubes are necessary for trouble-free operation.

It is a good policy in every central power station to inspect occasionally the air coolers, intercoolers, pumps, etc., all of which must also be cleaned periodically. Like steam turbines, it is also a sound maintenance procedure to inspect the blading of the gas turbine every few years. During a long "standstill," it is necessary to prevent moisture from getting to the gas turbine blading to cause corrosion.

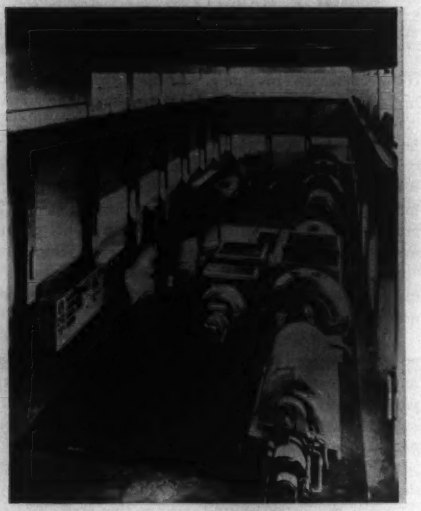
CONCLUSION

Based on the results of the operating experience accumulated through the years from 1939, when the first commercial gas turbine was put into operation until now, we can definitely say that the large gas turbine found a place in utilities and can be considered a reliable machine for power generation, either for the base load or for covering peak load.

From the fuel standpoint of view, natural gas seems to be ideal for this type of machine, because it does not

leave any deposit. While operating at a conservative gas temperature at 1,200 F it can be assumed that the operation of a gas turbine and its life is comparable with that of the steam turbine.

As liquid fuels, light oil can be burned without any doubt with practically the same reliability as natural



Courtesy Brown Boveri Corp.

Fig. 6. A 50,000 kw gas turbine plant, Livorno, Italy.

gas and other gases. Heavy fuel oils, especially Bunker C, tend to impose certain restrictions insofar as the operation is concerned at least for the base-load machine; namely, periodic shutdowns are necessary to remove deposits from the blading by washing.

In the areas where the desirability of burning two fuels is of importance, a special dual fuel burner can be applied. Such burners have been in successful operation already for many years.

The true comparison of the gas turbine versus the steam turbine can only be made on the plant-to-plant basis. Such factors as smaller area, smaller foundation, lower cubical volume figure of the complete plant can then be evaluated in favor of gas turbine.

As far as the maintenance is concerned, the figures show that it is in the order of about ⅓ that of a standard steam plant. This maintenance cost includes overhauling of the turbine every year, the necessary cleaning, etc.

In peaking service especially, the fast start and remote-control possibilities offer special economical consideration.

FUTURE CONSIDERATIONS

THE OBVIOUS TREND, as in the design of practically every machine, is to achieve larger and larger units with better and better efficiency. The largest unit built and operating thus far is the Beznau II unit with an output of 27,000 kw. The world's largest power plant is in Livorno, Italy, where two 25,000-kw gas turbines produce 50,000 kw. The next step will be Edmonton, Canada, which will have a capacity of 60,000 kw in two 30,000-kw units. Finally, Vancouver, B. C., Canada when built, is going to be the next world's largest gas turbine power plant—probably for a long time—as it will have four 30,000-kw gas turbines, with a total capability of 120,000 kw.

There is enough accumulated experience to build units larger than 30,000 kw. A 50,000-kw unit can be built readily occupying the same space as a 30,000-kw or 20,000-kw unit. It is ultimately possible even to build a 100,000-kw unit which will utilize approximately the same space and which would work on the principle of a combined steam and gas turbine cycle where the steam is generated at the supercritical conditions. An efficiency of over 45% of such cycle seems to be feasible.

Although today gas turbines have found a place of permanent existence in different branches of industry, with these large sizes, the utilities will be the most obvious place for their application.

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Split-Second Chemistry

An electronic instrument that can analyze an instantaneous sequence of chemical reactions such as take place in the explosion of rocket fuels is being produced by the Cincinnati Division of Bendix Aviation Corporation. The new device, called a "Time-of-Flight Mass Spectrometer," will have numerous applications in the science of missiles and rocketry, the processing and control of petroleum and chemicals, metallurgy, medicine, and research into many yet-unexplored areas.

It is extremely fast and can complete a chemical analysis in one ten-thousandths of a second. The instrument operates on the principle of instantly identifying vaporized gases, liquids and solids (including metals) by revealing their respective molecular masses.

The heart of the new instrument is a 4-foot metal vacuum tube called an "ion gun." Ionized molecules of the elements being analyzed are pulsed like radar signals from one end of the tube to the other and their speed, or "time of flight," is measured electronically and appears as a wave pattern—oscilloscope.

The Financial Return on Railway Electrification

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Regardless of its operational advantages, railway electrification, if it is to be used, should be justified economically. A simple, straightforward method is described for the computation of costs of railway electrification relative to diesel–electric operation.

IN THE PAST, railway electrification was applied in the United States to overcome limitations or difficulties generally involved with steam locomotive operation. Today electrification, when it is to be applied, must justify itself economically in comparison with diesel–electric operation, which already has superseded general steam operation.

The future type of electrification envisioned is no longer burdened with investment in power supply, transmission lines, or conversion equipment. It is powered directly from existing power supply systems and transmission networks with commercial frequency directly on the contact system. This system has the endorsement of the electrical section of the Association of American Railroads.

A simple chart has been prepared, from which any railroad can determine whether electrification offers any financial advantage for its operation and, if so, how much. To use this chart (Fig. 1), a few basic factors must be known:

1. How many locomotives and of what horsepower capacity are now required to handle the traffic over the mileage being considered for electrification?
2. What is the total track mileage that would be involved?
3. What is the average annual mileage made per locomotive?

From the total locomotive horsepower and the track mileage involved, the rail horsepower (rhp) per mile can be calculated. The rhp is generally taken as 82% of the rated diesel engine horsepower.

Two examples will serve to illustrate the use of the chart.

1. Railroad "X" has a single track main line 400 miles long. Approximately 500 miles of track would require a contact system. This line is now operated by forty 1750-hp (engine rating) road diesels, which make, on an average, 100,000 miles per year each. Should electrification be considered for this railroad?

The rhp per mile is first calculated. This is $40 \times 1750 \times 82\%/500$, or 115 rhp per mile. On the chart (Fig. 1) locate the point P_1 at the intersection of 115 rph per mile and the mileage, 100,000 per year. This point is well below any of the curves on the chart which show "per-cent return" on the additional investment required. Thus, electrification does not appear to be economically feasible for this railroad.

2. Railroad "Y" has a double-track main line 900 miles long. Approximately 2,000 miles of track would require a contact system. The present road motive power assigned to this route consists of 625 diesels averaging 1,500 hp each. The average mileage made annually by each unit is 75,000.

This rhp per mile is $625 \times 1500 \times 82\%/2{,}000$ or 385 rhp per mile. On the chart, this value of rhp per mile intersects the 75,000 annual mileage line at P_2, which is very nearly 24% return on the additional investment required for electrification.

A detailed study of all the advantages of electrification seems to be indicated in this case provided the present motive power is approaching the age for renewal, and provided electric power is available where needed along this railroad at a cost competitive with the cost of diesel fuel.

The chart has been prepared from the fundamental concept that the return R on any increase in investment made for electric operation over diesel operation is in per cent.

$$R = \frac{\text{difference in operating costs and fixed charges}}{\text{difference in total investment}} \times 100$$

All of the factors making up these differences may be expressed as functions of one or more of the following basic factors:

A. The miles of track to be considered as electrified to handle the required traffic. This determines the additional investment required for the contact line and any other costs related thereto, as well as the magnitude of the related maintenance and operating costs, and fixed charges.

B. The number and capacity (or rating) of the present motive power units, giving the total horsepower required to move the traffic with either form of motive

Full text of paper 58-32, "The Financial Return on Railway Electrification—An Approximate Method for Its Determination," presented at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Recommended for publication by the AIEE Land Transportation Committee. Scheduled for publication in AIEE *Applications and Industry*, 1958.

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power. A convenient unit for comparing the performance of various types of motive power is "1,000 continuous horsepower measured at the rim of the driving wheels," referred to in this discussion as "1,000 rail horsepower." It will be assumed in this discussion that the same number of 1,000-rhp units will be required to perform the same service *at the same speed* with either form of motive power. The difference in investment in motive power and the fixed charges thereon are determined by B.

C. The annual mileage made by the locomotive units as defined in paragraph B, in performing their work. Motive power operating costs are determined by both B and C.

It appears possible, therefore, by making certain assumptions as to the values of A, B, and C, to arrange these in an equation such that the return R on the difference in investment between the two types of operation, electric versus diesel, is expressed by some combination of functions of A, B, and C, or $R = f(A, B, C)$. A little thought will show that these three factors also determine "traffic density."

THE DIFFERENCE IN INVESTMENT

FOR ELECTRIC OPERATION, the investment involved consists of

1. The cost of the contact system (a function of A).
2. The cost of the power control and switching stations (a function of A).
3. The cost of signal and communication changes (a function of A).
4. The cost of the motive power (a function of B).

For diesel operation, the investment consists of the cost of motive power only (a function of B).

Let K_1 equal the cost per mile of all of the investment in foregoing 1, 2, and 3 for electrical operation and let K_2 be the difference in cost between diesel and electric motive power per 1,000-rhp unit. Then the total difference in investment becomes $K_1A - K_2B$. K_2 is negative because electric motive power should cost less than diesel on a rhp basis.

Estimates are available for the values of K_1 and K_2. The annual return R is to be calculated on this difference in investment.

THE DIFFERENCE IN OPERATING COSTS

THE MAJOR ITEMS of operating expense, wherein substantial differences may be found as between the two methods of operation, can be divided into two groups:

1. Favorable to Electric Operation
   - *a*. Locomotive maintenance expense
   - *b*. Engine house expense
   - *c*. Lubrication expense
   - *d*. Depreciation charges on motive power
   - *e*. Taxes and insurance on motive power
2. Unfavorable to Electric Operation
   - *f*. The operating and maintenance expenses of the contact system and associated facilities, as well as the depreciation charges thereon and any taxes

In some states, additions and betterments made to fixed railroad property are not subject to direct taxation.

In the not-too-distant future, there will be one more major item of operating expense which will show a differential favorable to electric operation, namely, the cost of electric power versus the cost of diesel fuel oil. At the present time in the United States, these costs are so very nearly equal for the usual load factors, that this factor can be disregarded in the present discussion. The trends of both of these energy costs, however, are too well known to need amplification.

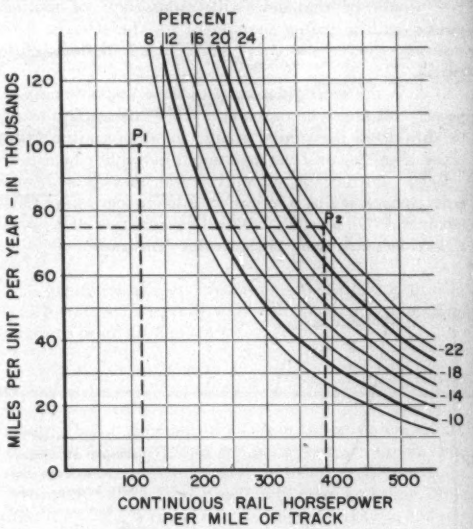

Fig. 1. Per-cent return on additional investment for electrification in terms of traffic density.

In combining and comparing all these costs, let K_D be the sum of the operating costs a, b, c enumerated previously for diesel operation, reduced to a "per 1000 rhp-mile" unit cost, and let K_E be the similar unit costs for electric operation. Also, let K_3 be the difference in these unit costs, which is always in favor of electric operation, $K_3 = K_D - K_E$.

The magnitude of the savings in these costs with electric operation is, therefore, the unit savings K_3 multiplied by the product of the number of "units" of motive power B and the annual mileage C, or K_3BC.

It will cost a certain amount, annually, to maintain and operate the electric contact system and power supply control. Let K_4 be this cost per mile per year. The total annual cost of this item becomes K_4A which must be subtracted from the operating savings K_3BC already indicated. K_4 is, therefore, negative.

Statistical data are available for the determination of the value of K_3 and K_4.

FIXED CHARGES AGAINST OPERATION

THE DEPRECIATION CHARGES for motive power is under Interstate Commerce Commission (ICC) accounting procedure; an annual charge against operating expense. Since electric motive power is known to have a longer economic life than diesel power, and since the investment is less for the same total horsepower, the depreciation charges will be substantially less with electric motive power.

Taxes on both types of motive power are generally based on the average valuation over the life. These will also be less with electric operation, inasmuch as the rate would be the same with either type of motive power, with a smaller investment for the electric. Any insurance factor also could be included in this differential.

If K_5 is the total differential in these costs for motive power, this factor becomes K_5B. From this amount must be subtracted the similar charge for depreciation (and taxes, if any) against the investment in the line facilities.

Let K_6 be the sum of depreciation, taxes, and insurance charges against the line investment per mile. This factor then becomes K_6A. The determination of K_5 and K_6 can be made from known values and rates.

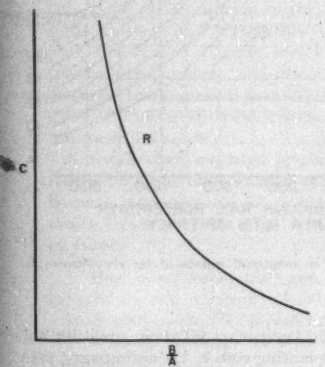

Fig. 2. Return on investment as a function of average annual mileage and rail horsepower per mile.

A = Track mileage under consideration for electrification
B = Total rail horsepower now being used to operate over mileage A
C = Average annual mileage made by present motive power in this service
B/A = Rail horsepower per mile
R = Return on the added investment for electrification, after depreciation, state and local taxes, insurance, and operating expenses, but before other financial charges

For the same service, i.e., the same ton-miles moved per year at the same speed, the total savings with electric operation becomes $K_3BC-K_4A+K_5B-K_6A$ or $K_3BC+K_5B-(K_4+K_6)A$.

The return R in per cent on the investment then becomes

$$R = \frac{K_3BC + K_5B - (K_4 + K_6)A}{K_1A - K_2B} \times 100$$

Because data are available for determining the values of K_1, K_2, K_3, K_4, K_5, and K_6, it now becomes possible by using C and B/A as co-ordinates to show R graphically for various values of A, B, and C as in Fig. 2.

The Fig. 1 chart has been made from the various values of the constants K_1 to K_6, inclusive, determined from carefully prepared and conservative estimates as to investment costs, and from data relative to known maintenance and other operating costs taken from a number of electrically operated and diesel operated railways in this country.

It is not intended that this chart should be regarded as the final answer to the economic problems involved with railway electrification. It simply serves as a general guide to show what traffic density presents economic possibilities, as well as where the traffic alone will not warrant the additional investment.

The financial return can be greater, generally, than that indicated, because of operation factors which are more favorable with electrification but which are not direct functions of the traffic density.

One of these factors is increased speed. In many cases, increased speeds would increase the financial return because (1) higher speeds will attract more high-revenue traffic now lost to competitive transportation agencies; (2) higher speeds would reduce the investment in car equipment, as well as motive power, although in some cases more electric horsepower than diesel horsepower would be required; (3) higher speeds would certainly cut down per-diem expense for cars.

In some cases, the economic effects of speed can be evaluated for a particular situation with much the same reasoning used to derive the general formula shown. In the same way, power costs when they become a major factor also can become a part of the "BC Factor."

Quite obviously, future economic conditions may dictate the calculation of a new family of curves showing the return. The general formula, with constants to suit the changed conditions, would still apply for the approximate solution of the general problem.

World's Biggest Electrode

The largest carbon electrode ever made is a 10-ton giant which measures more than 5 feet in diameter. This tremendous electrode was developed by the National Carbon Company, Niagara Falls, N. Y., a Division of Union Carbide Corporation, in anticipation of the future needs for larger electrodes for mammoth submerged arc furnaces that are now being designed.

On engineers' drawing boards are the designs for electric furnaces that will use as much as 50,000 kva of power in producing phosphorous, calcium carbide, and ferro alloys for the chemical and steel industries. Furnaces of this type use three 110-inch long carbon electrodes in order to conduct the high electric currents necessary for the operation.

Selection and Use of Servo Performance Criteria

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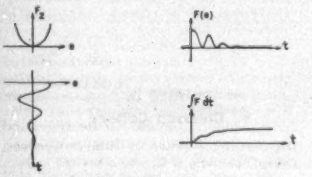

Fig. 1. Error measure for a criterion based on $F[e(t)] = e^2(t)$

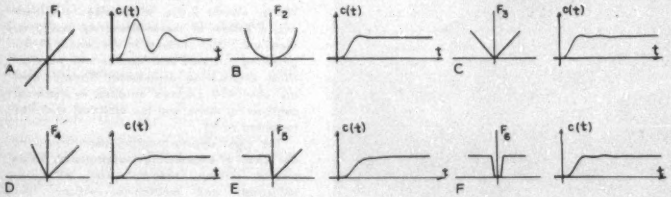

Fig. 2. Results of computer optimization of a fourth-order system. Optimum parameters for each criterion are: (a) $\alpha = 0.94$, $\delta = 0.132$, $\omega_0 = 1.435$; (b) $\alpha = 1.15$, $\delta = 0.324$, $\omega_0 = 1.480$; (c) $\alpha = 0.94$, $\delta = 0.191$, $\omega_0 = 1.575$; (d) $\alpha = 1.0$, $\delta = 0.160$, $\omega_0 = 1.687$; (e) $\alpha = 1.325$, $\delta = 0.325$, $\omega_0 = 1.553$; and (f) $\alpha = 1.01$, $\delta = 0.205$, $\omega_0 = 1.595$.

CONSIDERABLE IMPORTANCE has been placed on various types of integrals applied as performance criteria for analyzing and synthesizing servomechanisms. Among the integrals which have been proposed are

$$E = \int_0^\infty e^2(t)\,dt \tag{1}$$

$$E = \int_0^\infty |e(t)|\,dt \tag{2}$$

and, perhaps the most outstanding

$$E = \int_0^\infty t\,|e(t)|\,dt \tag{3}$$

Equation 3, called the integral of time multiplied by absolute error (ITAE), was proposed by Graham and Lathrop.

These integrals have found wide application in system design, and the form given in equation 1 has been modified and extended to include stationary random input signals. However, no general form of an error-measuring integral has been proposed which is simple to apply and at the same time flexible enough to include the many special requirements that arise in system design. As an example, consider a type-zero system, which has a steady-state error for a step input. All three integrals given are not directly applicable, inasmuch as they all would become infinite. To give another example, a system requirement may be such that although a steady-state error, constant or oscillatory, is permissible, the overshoot must not exceed a given maximum allowable amount. In order for a criterion to be general and still useful enough to include requirements of such cases as the ones previously discussed, the criterion must have great flexibility.

A general form of a measure of error is proposed which has such flexibility, as will now be shown. The measure of error is given by

$$E = \int_0^\infty F[(r(t) - c(t)), t]\,dt = \int_0^\infty F[e(t), t]\,dt. \tag{4}$$

where t is the time measured from the initiation of the transient input $r(t)$, and $c(t)$ is the system output. The difference between the input and output is called the error $e(t)$ and F is some function of error and time. Note that if $F[e(t),t]$ is equal to $e^2(t)$, the general form reduces to the integral of equation 1, whereas if $F[e(t),t]$ is equal to $t|e(t)|$, it reduces to the ITAE of equation 3.

In order to show the great flexibility of the general form, it is convenient to examine a geometric interpretation of the F function. Fig. 1 illustrates the graphical relationship between F and $e(t)$ for the integral of equation 1, and, although this particular F function has both a simple geometric form and a simply expressed analytical form, there is no reason to require the latter. Fig. 2 shows additional F functions, some of which do not have simply expressible analytical forms. Because each of the F functions shown in Fig. 2 emphasizes the error in a different manner, optimization of system parameters relative to each error measures results in a different set of parameters and, therefore, a different transient response. Associated with each F function in Fig. 2 is the resultant optimized transient response. The servo used for the illustration has on open-loop transfer function given by

$$G(s) = \frac{1}{s(s+\alpha)(s^3 + 2\delta\omega_0 s + \omega_0^2)} \tag{5}$$

Digest of paper 57-1033, recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., Oct. 7-11, 1957. Scheduled for publication in AIEE *Applications and Industry*, 1957.

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ELECTRICAL ENGINEERING EDUCATION

AIEE in Clemson College

THE STUDENT BRANCH OF AIEE at Clemson College, Clemson, S. C., was organized in December 1912, under the leadership of Dr. Walter Merritt Riggs, the College president and a Fellow of the Institute. At that time, there were 302 students in the School of Engineering and two staff members in the electrical engineering department. Today, there are over 450 students enrolled in electrical engineering alone and the electrical staff has increased to 11.

The eight degree-granting departments of the School of Engineering—agricultural, architecture, ceramic, chemical, civil, electrical, industrial, and mechanical—occupy four buildings, one of which, Riggs Hall, main engineering building, is shown at the left.

Last year, the large entering class of engineers increased the percentage of engineering students to 58.7%.

Technical Manpower Issues and Related Educational Problems

THE LETTER which follows, dated December 17, 1957, is addressed to Dr. J. R. Killian, Jr., Special Assistant to the President for Science and Technology, The White House, Washington, D. C.

Dear Dr. Killian:

On behalf of the Engineering Manpower Commission of Engineers Joint Council (EJC) and the Scientific Manpower Commission, we wish to extend our congratulations and best wishes to you on your appointment as Special Assistant to the President for Science and Technology.

For many years, the two Commissions have been struggling with the problems of motivation, utilization, and recognition of engineers and scientists—problems recently projected into a position of national importance and attention by international events. In the light of these events, the Engineering Manpower Commission, at its meeting of December 12, 1957, gave careful attention and consideration to the current situation and more particularly to the programs the Federal Government is developing to meet this situation, insofar as they are now publicly revealed. While we realize that this programming is still far from firm, you may wish to consider our thoughts on developments thus far discernible.

We believe that the technical manpower issues and related educational problems can best be understood when analyzed separately in terms of the short- and the long-range aspects, each having different implications and requiring dissimilar treatment. Thus far, most of the governmental activity as revealed to the public, has stressed solutions to essentially long-range problems—those related to education and basic research.

We concur—indeed, insist—that there are extremely important problems in these areas that demand attention. None the less, we find little enthusiasm in the engineering community for the launching of a Federal undergraduate scholarship program. Industrial and private attention to financial support of higher education is at an all-time high and with the increased participation of these sources it would indeed be regrettable to discourage them and reverse this trend. This will inevitably occur should the Federal Government start allocating funds for the same purposes. As you know so well, the large problem of engineering and scientific education today is not one of undergraduate student dearth. Indeed, there is great concern for the preservation of quality in engineering education as it attempts to meet the great student demands that exist now and that lie ahead with depleted faculties and overburdened facilities. These are some of the conclusions that clearly emerged at the Conference on Higher Education, Science, and Technology, held in Chicago, Ill., on October 31–November 2, 1957, and jointly sponsored by the National Science Foundation, the National Research Council, the Scientific Manpower Commission and EJC. including the American Society for Engineering Education (ASEE). In this regard, we strongly support and endorse the important recommendations recently made by the Committee on the Development of Engineering Faculties of the ASEE, a constituent society of EJC. We would also favor programs directed toward increasing the quality of graduate studies in engineering and science.

We fear that these long-range considerations may be diverting attention from the short-range problems and actions that could have more immediate results and which, therefore, should take precedence.

As you know, the general technological momentum in the United States has slowed materially in the past few months. Indeed, the announcement of the Soviet advances came at a time when we were trying to assess the effect of this slowing, not only in terms of individual displacement, but on arranged research and development teams in the universities and in industry throughout the country. There

is, in other words, a measurable softening in the demand for technical personnel at a time when programs are proposed to achieve increments in its work force. It seems clear that, given the proper challenge, American technology could impressively increase its obligation and output, without significant quantitative additions to its numbers. Happily, this appears to be particularly true in the very areas most intimately associated with research and development of most advanced weapons.

It is equally clear, however, that any significant increase in defense programming to meet the new challenge will again produce additional manpower needs. Should this indeed occur, important immediate measures should be considered—actions by industry, but primarily by Government. We have long stressed the manpower waste caused by improper utilization of technical personnel, and there is evidence that much has been accomplished to improve this situation in the past few years. More needs to be done and it is particularly appropriate that the President's Committee on Scientists and Engineers is sponsoring utilization conferences throughout the country. Encouraging progress will undoubtedly result from these programs and others that need expanded effort. As industrial utilization improves, however, it behooves us to note that during the past few years we have had other great manpower waste, the result of substantially outmoded military manpower procurement policies.

Indeed, we may be in danger of overlooking this fact and fail to avail ourselves of a largely unused resource of technical manpower, which could be quickly made available to Government, industry, and education. These are young engineers and scientists—many with impressive educational and professional backgrounds—who are still being diverted from technical pursuits by military procurement laws and regulations.

We do believe, of course, that the military should have in the uniformed services all the engineers and scientists needed as such, but our country cannot, we believe, continue to waste their talents on nontechnical duties. As a beginning in remedying this situation, and as additional manpower needs develop, we would strongly recommend:

1. The suspension of induction for military service of engineers and scientists and certain other groups having critical occupations. All things considered, it is our conviction that to expect the military to achieve a satisfactory level of utilization for engineers and scientists in an enlisted capacity places too great a burden on military personnel administrative process.

2. The release from the military of engineers and scientists not being utilized in their professional capacities, if they request such release.

3. The revision of ROTC assignment procedures to give priority for brief active duty training periods to engineering and scientific graduates after selections have been made to meet the military needs for technical billets and overriding nontechnical military specialists. It is anticipated that the release of enlisted engineers and scientists might increase military needs for ROTC graduates in technical billets. This, we believe, is all to the good.

4. Review of military retirement procedures to insure that the technical competence of experienced but relatively youthful officers is not lost to the military through premature and forced retirement in accordance with regulations having little pertinence to current and future Armed Forces technical requirements.

5. The development of a truly Professional Service for career engineers and scientists in the uniformed military services. It seems to us that this was a notable omission in the Cordiner Committee recommendations.

The implementation of these recommendations would not only release several thousand young technologists for work in their fields, but also would have salutary effects on the morals of those involved.

In essence, we maintain that the country has now the engineers and scientists necessary to accomplish the immediate task before us and we need only to develop and implement policies and plans to administer their talents properly. While thus reorganizing to meet current needs, we can weigh, with more deliberation, the longer range problems with greater assurance that change will really produce improvement.

We, of course, stand ready to elaborate on any of these considerations or to be of any assistance to you in your new tasks, and we trust you will feel free to call on us at your convenience.

Sincerely yours,

H. A. Meyerhoff,
Executive Director
Scientific Manpower Commission

G. E. Arnold,
Chairman
Engineering Manpower Commission of Engineers Joint Council

NSPE Nation-Wide Scholarship Program

Top officials of the National Society of Professional Engineers (NSPE) laid plans at a meeting in Kansas City, Mo., to implement their new nation-wide scholarship program.

Details are to be announced next Fall to high schools and to local NSPE chapters, with the first scholarships to be awarded to 1959 high school graduates, according to Leland Hobson, newly appointed chairman of the NSPE engineering scholarship committee.

This new nation-wide NSPE scholarship program was suggested by Armco Drainage and Metal Products, Inc., Middletown, Ohio. Armco is the first firm to implement a scholarship program through the NSPE (*Electrical Engineering*, January 1958, p. 100).

At the time of the initial announcement of the NSPE "Armco Plan," there was widespread interest from other industrial firms in a program of this type, it was explained by Mr. Hobson, who is associate director of the engineering experiment station at Kansas State College, Manhattan, Kans., and a former General Electric executive.

The NSPE scholarships will be based on need, the high school record, and local chapter recommendations following individual interviews of applicants. Finalists will be given aptitude tests.

Meeting with Mr. Hobson to outline the new scholarship program were G. H. Dyer, national NSPE president; C. A. Dunn, national vice-president; and P. H. Robbins, executive director.

Members of the scholarship committee who will serve with Mr. Hobson are R. A. Freese of Middletown, Ohio, and D. H. Pletta, of Virginia Polytechnic Institute, Blacksburg, Va.

The NSPE is the only national engineering society composed entirely of professional people representing all engineering professions. The NSPE currently has a membership of 40,000.

Electrical Engineering Education

NSF To Support In-Service Institutes

The National Science Foundation (NSF) has announced that it will accept proposals from universities and colleges interested in sponsoring In-Service Institutes for secondary school teachers of science and mathematics to be held during the academic year 1958-59.

A primary purpose of the In-Service Institute program is to assist colleges and universities in their efforts to encourage teachers in outlying school districts to take advantage of scientific training facilities not otherwise readily accessible to them. The NSF has already announced support of 125 Summer and Academic-Year Institutes in colleges and universities throughout the Nation during the summer of 1958 and the following school year.

These In-Service Institutes for secondary school teachers of science and mathematics will offer work in the subject matter of science and mathematics especially designed for these teachers. Institute meetings will be held outside of the regularly scheduled school hours—e.g., evenings, Saturdays, or late afternoons—so that teachers may attend while still teaching full time in their schools. A typical Institute might meet once a week for two hours for the full academic year of about 30 weeks. Half of these meetings might, for example, be devoted to laboratory work.

It is possible for a particular institution to offer courses in more than one subject-matter area in these In-Service Institute programs. Courses could be offered simultaneously, though not necessarily on the same evening, in mathematics, physics, chemistry, biology, etc., for instance. Any

Electrical Engineering Education

given participant should probably be limited to attending no more than two of these if he is to find time to do a good job on each. The In-Service Institute program contemplates that each group will be kept to less than 30 members so that discussion may be full and free.

NSF support to some 25 In-Service Institutes will cover all tuition and fees, plus any other direct costs to the college or university directly attributable to the program. Although the NSF does not provide stipend support for participants in the In-Service Institute program, the NSF grants provide funds to underwrite travel expenses in connection with attendance at the Institutes. Deadline for submission of completed proposals to the NSF is March 15, 1958. Directions for preparing proposals may be obtained from the Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D. C.

Engineering Careers in the Electric Power Field

In an effort to encourage top-flight engineering students to choose careers in the electric power field, a brochure entitled "The Challenge of Electric Power" is being distributed to every engineering school student in the 11 Western States by the 3 major Western associations—Pacific Coast Electrical Association, Northwest Electric Light & Power Association, and Rocky Mountain Electrical League.

The contents of the brochure are reprinted from the November 1957 issue of *Electrical West*, which presented a series of articles describing some of the challenging work being done by postwar engineering graduates in the electric power industry.

Carnegie Professor Awarded Late Patent for Radar Device

A Carnegie Institute of Technology professor has been awarded a patent after many years for a radar device which has been a standard feature in guided missile control since 1944.

Dr. E. M. Williams (M '47), head of electrical engineering at Carnegie Tech, has never made a penny on the invention because its only user, the United States Government, retained a royalty-free license. Nor could he receive official recognition of it from the patent office until a recent directive rescinded its secret designation.

Dr. Williams' development provided an improved means for directing a missile toward an airborne target. The original guide systems pointed their missiles toward the exact location of the target, then adjusted their aim as the target moved through the air. At close range, the missile was forced to change its direction so sharply that proper control could not be assured. Contact might fail if the missile were to fall behind the target and be unable to catch up with it.

By providing a system for calculating the target's motion through the sky, Dr. Williams enabled the missiles to direct themselves toward a predetermined advance position which the target and missile would reach simultaneously. The device eliminated much of the error which originally hampered missile development.

Dr. Williams holds over 100 patents on radar, guided missiles, photographic equipment, machine tools, electronic organs, and radio receivers, transmitters, and jamming devices. Currently, he is a consultant for the Department of Defense.

WISC at Work on Wisconsin Campus

Recently arrived WISC is now in operation on the University of Wisconsin (UW) campus, solving in one day problems which would require months by other means.

The WISC is the University's new large-scale electronic digital computer. Recently dedicated in a UW electrical engineering laboratory, WISC gets its nickname from the initial letters of its real name—Wisconsin Integrally Synchronized Computer.

Electronic computers like WISC are called other names, too, like "electric brain," "electric hand," or "giant moron."

The "electric hand" or the "giant moron" nicknames are more correct than the "electric brain" title, UW engineers say, because the computer works only under the guidance of the human brain, even though it does make some simple decisions for itself.

One engineer has stated that the machine can aptly be called a "problem child," inasmuch as it can solve its problems only under a lot of human guidance.

A dozen UW students, guided by their professors in the electrical engineering department, built the intricate subassemblies which make up the machine. The work has been done over the past six years as part of advanced electrical engineering training of the students.

The complex machine is made up of some 1,500 electronic tubes and hundreds of intertwined wires.

The UW-made WISC is a digital computer of "medium" speed. This means the machine can, for example, multiply two 10-digit numbers—say 8,954,733,274 times 9,673,486,843—and give the answer in 1/60th of one *second*.

The heart of the machine is the magnetic drum about two feet long and nine inches in diameter which revolves at 60 rps. On this drum, sections can be magnetized to store "orders" and numbers, just as they can be stored on recording tape.

In several important respects, WISC differs from existing machines. One is the use of "integral synchronization." Without this feature such a magnetic-drum computing machine would use one revolution to look up the instructions, one to look up the two numbers involved, one to perform the arithmetic called for, and a fourth to deliver the result. In the WISC these four operations are performed simultaneously, increasing speed of operation.

Another new feature in WISC is the built-in ability to work with a "floating decimal point." This means that the machine, although limited to 10-digit numbers, can "float" the decimal point over a range of 150 places during the operation. Thus, it can work more of the time at full precision—a feature which has to be "programmed in" in most machines, with resulting loss in speed.

Work on the UW computer was started in 1951 with funds from the Wisconsin Alumni Research Foundation, from the UW Engineering Experiment Station, and from University basic research funds. Total cost of the intricate machine is less than $100,000, considerably below the cost of other similar digital computing machines.

Chief purpose of the entire project is to train young engineers in this highly important and rapidly growing field. It has been found that WISC also provides a useful addition to the International Business Machines Company computing equipment now operated on the campus by members of the Numerical Analysis Laboratory. It also helps the University to increase its service to industry in the State.

Du Pont Program of Aid to Education

Grants totaling nearly $1.15 million have been awarded to 135 universities and colleges in Du Pont's annual program of aid to education, the company announced recently. The total for the next academic year is about $100,000 more than Du Pont contributed for this school year.

Most of the increase and more than half of the entire program are grants to colleges and universities for strengthening the education of scientists and engineers. These grants will support the teaching of science and mathematics as well as other subjects. At the same time, grants for fundamental research are being continued, as are grants for fellowships, which once made up the entire plan. Du Pont's program dates from 1918.

As in previous years, decisions on the use of the funds and the selection of people to receive individual grants are left to the institutions.

In recent years, discussions with educators have indicated that maintaining high standards of teaching is a major problem at all levels of education in view of higher costs and increasing enrollments. Du Pont's grants for advancing teaching, which proved effective in science, mathematics, and other liberal arts courses, are now being extended to medical schools for the first time.

The major parts of the program are: *Grants for Teaching*. These total about $664,000 in awards to more than 100

privately controlled colleges and universities, including 12 medical schools, as follows: (1) $4,000 each to 73 colleges to help maintain their records of strength in chemical or technical education where each grant includes $2,500 for chemistry teaching and $1,500 for other subjects; (2) $4,000 each to 23 major universities to help strengthen undergraduate teaching of courses that contribute to scientific and engineering education; (3) $3,000 each to 12 medical schools to support education and research in biochemistry, a preclinical science of constantly increasing importance to medicine; (4) $169,000 for 43 postgraduate teaching assistantships, mostly in chemistry, shared by 39 universities; and (5) $75,000 for fellowships and scholarships for prospective high school teachers of science and mathematics which includes 26 postgraduate fellowships at 7 universities and about 50 summer scholarships for undergraduates at 6 colleges.

Aid to Fundamental Research. This totals $309,000 and includes, in large part: (1) $15,000 each to 10 universities and $10,000 each to 10 others for fundamental research of their own choosing in chemistry; and (2) $1,500 each to 26 universities to enable individual staff members to undertake summer research of their own choosing in chemistry or chemical engineering.

Postgraduate Fellowships. $155,000 for 40 fellowships in science and engineering to be shared by 25 universities.

Grants for other university work round out the total program.

Nuclear Energy Courses for High School Teachers

For the second year, Argonne National Laboratory, Lemont, Ill., will provide an opportunity for high school teachers to review the fundamentals of nuclear energy and to be made aware of the latest developments in this field of science. Four sessions, each spanning a 2½-week period, will be offered.

The courses are tentatively set to run from June 9 through August 27, with final dates dependent on the number of teachers enrolled for each session. Tentative dates are June 9-25, June 30-July 17, July 21-August 6, and August 11-27.

The teachers will hear lectures by Argonne scientists and will perform experiments dealing with physics, chemistry, biology, and metallurgy, all as related to atomic energy.

They will visit such Laboratory facilities as the Experimental Boiling Water Reactor, first reactor in the Atomic Energy Commission's (AEC) power reactor program to be completed; research reactors; the "Argonaut," an atomic reactor designed for college graduate training; and the "iron room," where the radioactive content of humans is measured.

The courses are sponsored by the Argonne chapter of the Scientific Research Society of America. The courses were organized to help narrow the gap between the training of many high school teachers and the current state of scientific knowledge.

Some 40 midwestern high school and junior college teachers attended the first two courses conducted at Argonne during the summer of 1957.

Inquiries about the courses should be directed to Dr. E. W. Phelan, Laboratory Director's Office, Argonne National Laboratory, P. O. Box 299, Lemont, Ill. Sole expense will be a $10 individual registration fee. Participating teachers are expected to arrange for their own accommodations in the Chicago area.

Operated by the University of Chicago under contract with the AEC, Argonne National Laboratory is situated 25 miles southwest of Chicago. It employs a staff of 2,700 in research and related activities.

Work in progress covers atomic energy research in several fields: physics, chemistry, biology and medicine, reactor engineering, applied mathematics, chemical engineering, metallurgy, remote control engineering, and electronics.

Electrical Engineering Education

Also at Argonne National Laboratory is the International School of Nuclear Science and Engineering. The School is operated under President Eisenhower's "Atoms for Peace" program and is the only institution of its kind in the United States. It provides foreign and domestic graduate students and engineers with the opportunity to study the scientific and engineering fundamentals pertaining to the development of atomic energy for peaceful purposes.

An Electrical Engineer in Industry

R. L. OETTING (AM '37, M '45), manager, Lighting Institute, General Electric Company (GE), Nela Park, Cleveland, Ohio

"Membership in the AIEE has meant much to me and can be summarized in three categories. First: I have kept up on progress not only in my field of specialization, but also in the other fields. The tremendous breadth of Institute interests and activities is of inestimable professional value. Second: Since the conduct of our technical program demands all sorts of operational and administrative activities, Institute membership has offered exceptional opportunities for personal development in these areas. Last: I value the personal contacts—many have deepened into close friendships. Associating with colleagues just starting, well along, and rounding out their professional careers is a stimulating, satisfying part of AIEE membership."

Mr. Oetting is a graduate of the University of Wisconsin, having received his B.S. degree in 1936 and his professional E.E. degree in 1948. While an undergraduate, he was active in theater and radio production work. It served him well in 1936 when a knowledge of 35-mm sound movie projectors was almost more important than his engineering in finding a job with the GE Lighting Institute. Within a year, though, he was transferred to application engineering activities, working first in the photometric laboratories and later in writing technical publications on lighting. He was then transferred to field engineering work, assisting northern Ohio industries with their wartime lighting and inspection problems. A year later, he was brought back from the field to the lamp development laboratories at Nela Park where he engaged in electronic tube work for radar and proximity fuse applications. He then returned to application engineering to work with various defense services on wartime lighting problems. These activities developed into miniature lamp applications when hostilities ceased. Then came a transfer to the application of lighting for public buildings and for offices in particular for Mr. Oetting. From office lighting, his duties were changed to interpreting engineering data into "sales aids" for GE's lamp marketing groups and, since January 1955, he has been manager of the unique Nela Park lighting education facility, the GE Lighting Institute.

Highlights of Mr. Oetting's association with the AIEE include a year as chairman of the Wisconsin Student Branch and a year as chairman of the AIEE Cleveland Section. He has served on the following Institute Committees: Production and Application of Light (1947-55, chairman 1953-55); Liaison Representative on Standards Committee (1951-55); Public Relations (1952-55); General Applications Division (1953-57, chairman 1955-57); Award of Institute Prizes (1954-55); Technical Operations (1955-57); and Joint Division Committee on Automation and Data Processing (1956-57).

Electrical Engineering Education

Student Develops New Loudspeaker "Throat"

A new loudspeaker "throat" that eliminates the problem of distortion in high frequency horn loudspeakers, has been developed by a Northwestern University mechanical engineering student.

The Avedon Sonophase throat, incorporated into three high-frequency loudspeakers now in production by Electro-Voice Inc., Buchanan, Mich., was designed by R. C. Avedon, 24, of Northbrook, Ill. He is a senior at Northwestern's Technological Institute.

Mr. Avedon also designed the speakers in which this throat is used. The throat is the portion of the loudspeaker between the diaphragm and horn, which has been a trouble spot in accurate high frequency reproduction.

The student developed the new design while on co-operative assignment at Electro-Voice. Under the 5-year engineering curriculum at the Technological Institute, students spend 6 quarters as employees of participating firms to supplement the 12 quarters of classroom and laboratory work at the Technological Institute.

Mr. Avedon's design overcomes the problem of diaphragm deformation, common in apparatus used at high frequencies when the diaphragm's motion becomes distorted at the very high frequencies.

In the new throat, sound from each portion of the diaphragm is channeled through separate paths of definite relative lengths which converge into a proper balance upon reaching the horn.

55 Grants Awarded by AEC

L. L. Strauss, chairman of the Atomic Energy Commission (AEC), announced on January 8, 1958, approval of grants totaling $3,499,638 to 55 colleges and universities in the United States to be used to expand training facilities for increasing numbers of nuclear scientists and engineers.

This brings to $6,764,388 the total amount for 91 training grants made by the AEC during the past 10 months, to 68 educational institutions.

The grants are a part of the AEC's assistance program to encourage colleges and universities to establish curriculums or to broaden already established study programs for the purpose of easing the shortage of trained manpower in the atomic energy field. The funds will be applied toward the purchase of laboratory equipment.

These awards are the third in a series of grants under this program which was announced on September 4, 1956. The first award to 15 colleges and universities totalling $1,193,450 was announced on March 4, 1957. The second of the series totalling $2,071,300 was made to 21 educational institutions on May 10, 1957.

More than 100 applications have been received since the program was inaugurated. Some proposals, received too late for evaluation prior to the third-round announcement, are under study.

The grants that have been announced provide for small training reactors at seven educational institutions: University of Arizona, University of California at Los Angeles, University of Delaware, University of Missouri School of Mines and Metallurgy, Ohio State University, Oregon State College and University of Wyoming. Each of the institutions will be required to obtain licenses to operate the reactors.

Grants for the purchase or construction of nuclear reactors for science and engineering education are made only to colleges or universities which conduct studies in nuclear technology at the graduate level and are accredited by the Engineers' Council for Professional Development.

In addition to the grants, the AEC has made loans of nuclear materials, such as uranium metal to furnish fuel for the reactors, and neutron sources to colleges and universities. This includes furnishing fuel elements for research reactors and subcritical assemblies without charge.

The AEC also supports fellowships, finances research projects at colleges and universities, and operates a number of training programs in nuclear technology for students and teachers.

Record Aids Program of Scientific Education

General Dynamics Corporation, builder of the atomic-powered submarines *Nautilus* and *Seawolf* and the Atlas Intercontinental Ballistic Missile, has begun distribution of a long-playing record by Dr. Edward Teller, world famed "architect of the H-bomb" on "The Size and Nature of the Universe" and "The Theory of Relativity."

Distribution will be made to 3,500 colleges and secondary schools, according to Frank Pace, Jr., president, in connection with the corporation's over-all program of scientific education designed to stimulate the scientific curiosity of American high school and college students. Dr. Teller, one of the world's leading nuclear physicists, is a consulting theoretician to General Dynamics and is well-known for his outspoken views on the nation's present scientific crisis.

Included with the 33-rpm recording is a new "Map of the Heavens" prepared by the National Geographic Society, depicting almost 2,000 stars and 88 constellations and a picture-caption booklet, "The Atomic Revolution," published by the corporation, which explains the theory and peaceful uses of nuclear fission and fusion.

In clear and simple language Dr. Teller summarizes the basic features of scientific theory concerning the universe and relativity in terms understandable to the layman. Mysteries of space and time are presented as a series of fascinating puzzles and surprises difficult to comprehend more because they are at variance with customary human experience than because of their complexity. Each lecture runs for about 30 minutes.

Short Course in Quality Control

The 11th annual short course in Quality Control by Statistical Methods is being offered by the College of Engineering, University of Illinois, with the co-operation of the Division of Engineering Extension at Urbana, Ill., March 10-20, 1958. Intensive work will be given in the fields of control charts and acceptance sampling with some attention paid to the rational setting of specifications and tolerances. It is designed for those in the areas of design, production, procurement, management, quality control, and inspection.

For further information, write to: Prof. J. A. Henry, Room 205, Mechanical Engineering Laboratory, University of Illinois, Urbana, Ill.

FIER Awards Grant to New Stanford Research Laboratory

In recognition of the urgent need for basic research in the measurement and automatic control aspects of aeronautics, the Foundation for Instrumentation Education and Research (FIER) has awarded a grant of $1,200 to the newly established Aerodynamics Physical Measurements Laboratory at Stanford University. According to Dr. F. E. Terman, dean of engineering and provost of the University, the grant will be matched with a similar sum by Stanford and will be used for "the development of a shock tube and associated high-speed photographic equipment for taking schlieren and shadow pictures of shock waves and for making other specialized aerodynamic measurements."

Stanford's new laboratory, which went into operation late in 1957, was developed to meet the measurement and aeromatic control challenges imposed by the missile age. For example, an adequate treatment of the aerodynamic heating experienced by a missile traveling at 20 times the speed of sound at 100,000 feet altitude must include consideration of radiation physics, chemical kinematics, atomic transport phenomena, electrical effects in high-temperature gases, and thermal properties of materials—subjects which have been justifiably ignored in aerodynamic measurements of the past. Hence, in modern aeronautical research, one finds the shock tube and other facilities taking their place beside the wind tunnel; while the spectroscope, the microsecond surface thermometer, the streak camera, etc., are joining the wind-tunnel balance and the pitotstatic tube as important measuring devices.

The specialized measurements laboratory, which occupies about 2,000 square

feet in a building adjacent to the present Guggenheim Aeronautical Laboratory, will meet the challenge in two aspects: it will develop experimental devices to simulate current flight problems and to help define the problems of the future, and it will provide training to students in the use of these new devices and their associated instrumentation.

FIER selected Stanford for its award after studying programs in aeronautical engineering in 15 universities. In the words of FIER trustees, "The Stanford proposal for use of our modest grant was outstanding in that it involved a new and excellently planned program and combined two important objectives of the Foundation—the need for basic research and formal education in measurement and control."

Funds for the Stanford grant originally came to FIER from the North Texas Section of the Instrument Society of America.

Columbia Professor Honored by the "Great Teacher Award"

Prof. M. D. Hassialis of the Columbia University School of Mines was one of two faculty members to be honored by the Columbia University Society of Older Graduates, when given the "Great Teacher Award."

The society, made up of 700 graduates who received their degrees 30 years or more ago, presented the awards at its 47th Annual Dinner. Members are all graduates from Columbia College or the School of Engineering and have continued their active interest in the University.

Prof. Hassialis, a 1931 Columbia College graduate, joined the faculty of the School of Mines in 1937. He was a member of the United States delegation to the 1955 Geneva Conference on the Peaceful Uses of Atomic Energy.

He is a member of the recently formed Council for Atomic Age Studies (*Electrical Engineering*, March 1957, p. 260).

Engineering Students Inspect New Power Plant

On December 14, 1957, the University of Arizona's Joint Student Branch AIEE—Institute of Radio Engineers (IRE) members were guests of the Tucson Gas, Electric Light and Power Company at the company's South Alvernon generating site. Approximately 65 students attended.

At present, the Old Pueblo's utility company is building a new 75,000-kw turbo-generating plant which is expected to be put "on the line" in May 1958.

N. "Mitch" Lovell, vice-president of the company in charge of the electrical department, spoke to the group on December 10 regarding the Company's future plans and "Engineering Decisions Associated with Power Plant Design." Mr. Lovell also gave the group hints on the unique things to observe during the aforementioned field trip. Because of the Southwest's turbulent thunderstorms, the new site will be equipped with the Peterson Coil ground fault neutralizer array.

In February, Dr. E. F. Carpenter, head of the astronomy department and director of Steward Observatory, spoke to the Student Branch on the progress and plans of the International Geophysical Year.

Dr. Mingins Named Head of LTI Engineering Division

Dr. C. R. Mingins was appointed chairman of the Division of Engineering at Lowell Technological Institute (LTI) by the Board of Trustees at their quarterly meeting, Dr. M. J. Lydon, president, has announced. In this capacity, Dr. Mingins, replacing Prof. H. C. Brown who retired, will co-ordinate and administrate the work of the departments of electronic engineering, general engineering, leather engineering, paper engineering, textile engineering, and physics and mathematics.

Dr. Mingins had 13 years of teaching experience as professor at Tufts before joining LTI, where he also heads the department of physics and mathematics, on September 1, 1956. He obtained the A.B. degree in physics at Wesleyan University in 1925 and the Ph.D. in physics at Cornell in 1935, has a number of publications to his credit, and is actively engaged in fundamental research.

NSF Awards Two Grants for Research Reactors

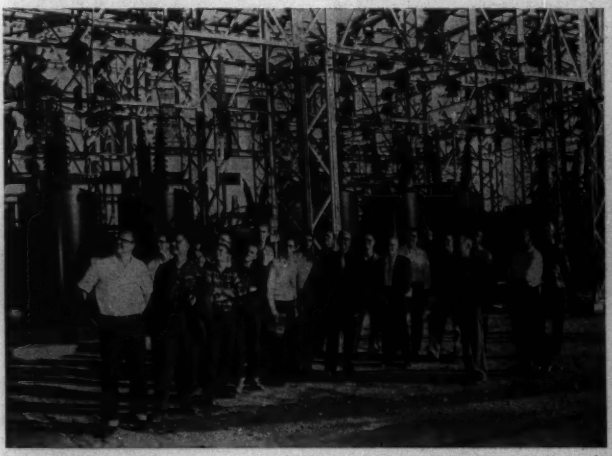
Two major grants for research reactors have been announced by A. T. Waterman, director of the National Science Foundation (NSF): a $300,000 grant to the State College of Washington, at Pullman; and a $150,000 grant to the University of Virginia, at Charlottesville. In announcing the grants, Dr. Waterman said: "Modern

Electrical Engineering Education

nuclear research has been handicapped by the lack of reactors for purely research purposes at academic institutions. Universities lack funds to provide the large and costly reactor research facilities required for pure research and training purposes in nuclear physics." In both the Washington and Virginia facilities, the Federal Government is supplementing the funds being provided by the universities themselves—more than half the cost being borne in each case by the respective university.

The reactor facility to be constructed at the State College of Washington will be a swimming-pool type, heterogenous reactor using enriched fuel elements and moderated by water. The reactor will have 12 beam ports, a thermal column, and at a power level of 100 kw will provide a core flux of about 10^{12} neutrons per cm^2 per second.

The State College of Washington has been planning the establishment of a nuclear reactor facility since 1954. The over-all project is under the direction of H. W. Dodgen, department of chemistry. The following are some of the problems currently interesting the staff: genetic effects of nuclear radiations, under Dr. R. A. Nilan; uptake of iodine in cattle, under Dr. W. E. Ham and Dr. M. W. Galgan; absorption and translocation of isotopes in plants, under Dr. O. Biddulph; effects of nuclear radiation on enzymes, under Dr. H. B. Milne; isotope exchange reactions and complexion studies, under



Manley Commercial Photography

THE UNIVERSITY OF ARIZONA'S Joint Student Branch AIEE-IRE visited the Tucson Gas, Electric Light and Power Company's new South Alvernon generating plant on December 14. The 75,000-kw plant is expected to be put "on the line" in May 1958.

Electrical Engineering Education

Dr. J. P. Hunt and Dr. H. W. Dodgen; neutron diffraction studies, under Dr. E. L. Wagner; and labeled insecticide studies on insects, plants, and soils, under Dr. R. F. Harwood.

The projected facility is near seven other institutions of higher learning and is expected to contribute to the development of a regional program in reactor research and training in nuclear technology. The facility also is being assisted by the U. S. Atomic Energy Commission (AEC).

The research reactor at the University of Virginia also will be of a swimming-pool type and is similar in a general way to the facility to be constructed at the State College of Washington. The University of Virginia School of Engineering is participating in the design and construction of the reactor, thereby making possible appreciable savings in cost. The facility is under the direction of L. R. Quarles, dean of the School of Engineering. The staff has been actively planning research with nuclear radiation in the fields of biology, chemistry, engineering, medicine, and physics. Among the problems engaging their attention are: mutations in seeds caused by neutron irradiation, under Dr. W. R. Singleton; radiation effects on oxidation and corrosion inhibitors, under Dr. J. W. Cole; metabolic action of the thyroid hormone, under Dr. Gemmill; effect of neutron bombardment on the tensile strength of thin films, under Dr. J. W. Beams; circular polarization of gamma rays, under Dr. F. L. Hereford and Dr. S. Berko; and neutron lifetimes in reactor structures, under Dr. L. R. Quarles.

In the case of both facilities, nuclear fuel will be provided by the AEC.

RCA Grants Fellowships to Nine Graduate Students

The Radio Corporation of America (RCA) has awarded RCA Fellowships to nine university graduate students for advanced studies in engineering, physics, and dramatic arts, Dr. C. B. Jolliffe, RCA vice-president and chairman of the RCA Education Committee announced recently.

"These fellowships have the double purpose of assisting students to obtain advanced degrees in arts and sciences related to the electronics industry and of increasing the number and quality of trained scientific personnel in this country," Dr. Jolliffe said.

More than 120 students have received the awards since the RCA Fellowships were inaugurated in 1947. Each Fellowship is valued at approximately $3,500. It includes full tuition costs, $2,100 toward the student's living expenses, and $750 as an unrestricted gift to the university attended by the RCA Fellow.

Seven of the fellowships are awarded for graduate study and research in physics, electrical engineering, and engineering physics. Two RCA–NBC Fellowships are awarded jointly by RCA and the National Broadcasting Company (NBC) for advanced work in dramatic arts.

The recipients of RCA Fellowships and RCA–NBC Fellowships are pursuing graduate studies at New York University, Columbia University, California Institute of Technology, Cornell University, University of Illinois, Princeton University, Rutgers University, Carnegie Institute of Technology, and Yale University.

University of Frankfurt Nuclear Research Reactor

A 50-kw nuclear research reactor located at the University of Frankfurt, West Germany, began operating on January 10, it was announced by Atomics International, a Division of North American Aviation, Inc., designer and builder of the reactor.

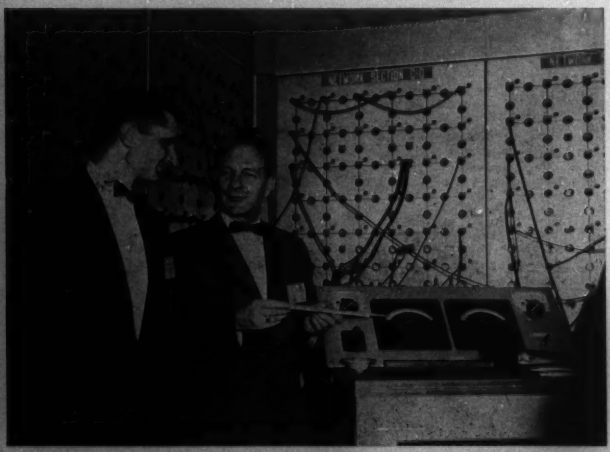
The nuclear reactor is a "solution type" which uses enriched U-235 in a water solution as fuel. Design features include a completely enclosed gas-handling system which contains all radioactive products. No radioactive materials are released to the atmosphere.

The reactor will be used for radiochemistry, materials and medical research, general research in the nuclear field, and the production of radioisotopes at the University. It was built by Atomics International for the University, under contract with the German firm of Farbwerke Hoechst.

Atomics International has built and placed in operation seven other research reactors similar to the one for Frankfurt. These include a training reactor located at the company's Canoga Park (Calif.) plant, two reactors operated by the company for the Atomic Energy Commission (AEC), and another built for the AEC's laboratories in Livermore, Calif. Also included is the first reactor built for private industrial research, located at the Armour Research Foundation, Chicago, Ill.

Other research reactors built by Atomics International for foreign installation include one built for the Japan Atomic Energy Research Institute, operating near Tokyo. Another was built for the Danish Atomic Energy Commission and is in operation near Copenhagen. The foreign installations are using reactor fuel supplied through the United States' Atoms-for-Peace program. Atomics International is also building a research reactor for the Institute for Nuclear Research located in West Berlin, and another for the Enrico Fermi Nuclear Study Center in Milan, Italy.

Gas Companies Gift to Tufts



"SPUTNIK is quite a scientific achievement . . . we will agree," says Worcester (Mass.) Division Manager J. P. Wood (*right*) to Framingham (Mass.) Division Manager Donald Story (*left*) of the Worcester Gas Light Company, "but it takes nothing away from the mechanical brain of the gas industry." Both Mr. Wood and Mr. Story were on hand at the recent dedication of the McIlroy Fluid Network Analyzer, presented to Tufts University in Medford, Mass., by 17 Massachusetts gas companies. Its use by engineers will eliminate long, tedious mathematical calculations and will quickly determine size and location of existing and future gas service mains. The giant (100-foot long) machine and an accompanying collegiate scholarship coincide with the expressed desires of the President of the United States for industry and business to encourage engineering studies.

INSTITUTE ACTIVITIES

Tulsa, Oil Capital of the World, Will Be Host to South West District Meeting

TULSA, oil capital of the world and center of the "Magic Empire" region of northeastern Oklahoma, will be host to the AIEE District No. 7 Annual Meeting, March 31-April 2, 1958.

Tulsa, one of the Southwest's fastest growing cities, is the heart of the "Magic Empire." Oklahoma's finest playground and largest industrial area. It is the home of over 800 oil companies and firms closely allied with the petroleum industry. Tulsa also is proud of the fact that despite its mushroom growth from a population of 1,390 in 1900 to 264,300 in 1958, it is nationally acclaimed as one of America's cleanest and most beautiful cities.

The program of the South West District Meeting has been designed to be of interest to all members in the Southwest and will include sessions on aircraft, engineering education, petroleum products, petroleum manufacturing, power generation, transmission, distribution, secondary distribution, and substation design as well as industrial applications and communications. An excellent program of tours of local sites of interest has also been arranged.

General Session

After a welcoming address by the Hon. G. E. Norvell, mayor of the City of Tulsa, the keynote address, "The Electrical Industry and the Southwest," will be given by R. K. Lane, chairman of the board of directors, Public Service Company of Oklahoma. N. F. Rode, vice-president, District No. 7, will preside at this session which will be held at 10 a.m. in the Crystal Ballroom of the Mayo Hotel. There will also be a word from Institute President W. J. Barrett at this opening session.

The luncheon meeting at noon on Monday will be held jointly with the Engineers Club of Tulsa at which the Hon. H. M. Milton II, assistant secretary of the Army, will be the speaker.

Entertainment

On Monday evening, an informal reception and fellowship hour, compliments of Public Service Company of Oklahoma, will be held in the Crystal Ballroom of the Mayo Hotel at 6 p.m. Background music will be provided by an orchestra and refreshments will be served. Registrants and their ladies are invited. There will be no admission charge; however, admission will be by badge only.

Tuesday evening is planned to be the entertainment highlight of the convention. An informal banquet will be held in the Crystal Ballroom with all convention registrants and their ladies invited to attend. Dinner music will be provided by an orchestra with the main entertainment program presented by the University of Tulsa Choral Group and theatrical departments. A very interesting and entertaining program is anticipated. Tickets will be sold Monday and Tuesday at the registration desk at $7.50 per person.

Sports

Golf will be arranged for those desiring to participate. These arrangements can be made through the inspection trip committee.

Ladies Activities

Monday, March 31

9:00 a.m. Registration, Mayo Hotel. All ladies should register with their husbands before signing up for the program.

12:00 Noon. Buffet Luncheon and Fur Style Show and Lecture on Furs, Pompeian Court, Mayo Hotel.

6:00 p.m. Informal Reception and Get Acquainted Party, Crystal Ballroom, Mayo Hotel.

Tuesday, April 1

9:30 a.m. Board buses for tour of famous Frankhoma Pottery Works. Buses then proceed to Oaks Country Club for buffet luncheon at 12:00 noon, with bridge, canasta, and golf following in the afternoon. (Tickets for tour and luncheon are $2—green fees not included.)

7:00 p.m. Banquet.

Wednesday, April 2

9:30 a.m. Board buses for tour of Philbrook Art Center and tour of Gilcrease Museum of Indian Art.

12:00 Noon. Buses return to hotel.

Inspection Trips

Five tours have been arranged for those registrants and ladies interested in visiting local installations of interest. Tickets will be available at the registration desk for each of these trips. Tickets should be obtained as soon as possible. A nominal charge will be made for tickets for those tours which require transportation.

Douglas Aircraft Company, Tulsa Division (Tuesday, 2 p.m.). The tour will be made of the main assembly building and will include the fabrication area, wiring development and subassembly area, and main assembly line. The main assembly building is over 5,000 feet long. Douglas Tulsa Division is a major contractor for the modification of the Air Force Type *B-66* and *B-47* Bombers. Wives of members are invited to make this tour.

Nelson Electric Manufacturing Company Plant and Offices (Tuesday, 2 p.m.). Located on a 58-acre tract southeast of Tulsa, a new million dollar building houses the largest manufacturing facilities of electrical control equipment in the entire region. The 22,000 square feet of air conditioned office space are combined with a plant 400 feet long by 180 feet wide. High and low voltage switchgear, motor starters, explosion proof equipment, and oil field specialty items are the company's principal products. Application and design engineering, production control, electrical, sheet metal, welding, and machine shop will be included in the departments visited. Equipment in various stages of manufacture will be inspected.

Skipper's House of Photography

SKYLINE of Tulsa, Okla., where the AIEE South West District Meeting will be held, March 31-April 2, 1958. Headquarters for the meeting will be the Mayo Hotel.

Public Service Company of Oklahoma, Tulsa Power Station (Monday, 2 p.m.). A brief introductory talk illustrated with a number of slides will precede the tour.

This station includes a 175,000-kw turbogenerator unit that has been in operation for one year, a second 175,000-kw unit in the final stages of construction, and a 45,000 kw compound unit just completed.

In addition to the turbine-generator units, the electrical equipment that will be seen includes 3,000-hp boiler feed motors, 1,750-hp draft fan motors, 1,500-hp circulating water pump motors, 1,600-hp, 1,125-kw motor-generator exciter, 8,000-ampere generator bus duct, 480-volt substation, central control unit, and other electrical and mechanical equipment of interest.

D-X Sunray Oil Company, West Tulsa Refinery. A guided tour is planned through Oklahoma's largest refinery where 75,000 barrels of crude oil are processed each day. Lubricating gasolines, motor oils, and hundreds of other products derived from petroleum are produced at this refinery.

The planned stops during this tour include the main substation where two 500-mva, 14.4-kv, outdoor circuit breakers have recently been installed, a catalytic cracking unit, the canning plant where 400 quarts of oil per minute are canned on one machine, a new high-frequency alkylation unit, a new platformer, a new unifiner, a new isomerization unit, and the recently expanded and modernized laboratory.

The refinery is served by three 13,200-volt lines from the local utility system. The motor connected load is approximately 15,000 hp. The substation capacity is 15,150 kva at 13,800 volts with a maximum demand of 11,000 kw when the new units are placed on stream.

Southwestern Bell Telephone Company New Long Distance Telephone Building. This building represents three years of work, hundreds of thousands of man hours, and an expenditure of $7.5 million. The fantastic electronic long-distance machine connects Tulsa with 44 similar machines in the United States and Canada. The Tulsa operator can dial more than 25 million telephones direct.

The new "4A" switching machine—a superhuman telephone crossroads—automatically determines the best route for the calls and sends the electrical impulses along the proper set of wires into a telephone switching center miles away and rings a telephone just as if the call had been dialed locally.

Other new equipment includes special billing machines designed for telephone use, a printing press which transforms a roll of blank paper into a telephone bill with the proper amount printed thereon, a centipede like machine which picks up the bills by vacuum, opens the envelope, inserts the bill, moistens the flap, seals and stacks them in a neat bundle for mailing.

This tour will be held Monday and Tuesday afternoons at 2 p.m. and Tuesday morning at 10 a.m. Each group of 10 will meet at the Long Distance Building and be conducted on the tour by a guide. If sufficient numbers sign up for this tour additional times will be scheduled. There is no transportation charge for this tour as it is located close to the headquarters hotel.

Hotel Reservations

All rooms for members and guests have been arranged at Headquarters hotel, the Mayo. Reservations are to be made directly with the hotel using the reservation cards which will be included in the regular meeting notices. Rates, indicated on the cards, are as follows.

Room*	Cost		
Single for 1	$ 8	$ 9	$12
Double for 2 (Double Bed)	11	12	15
Double for 2 (Twin Beds) $12	14	16	18
Parlor Suites (Parlor and 1 Bedroom)	30	to	50
Parlor Suites (Parlor and 2 Bedrooms).	40	to	60

*All Rooms have private baths

Registration

The registration desk will open at 7:45 a.m. on Monday, March 31, in the main lobby of Headquarters, the Mayo Hotel. This desk will be staffed from 7:45 a.m. to 5:00 p.m. on Monday, March 31; from 8:00 a.m. to 5:00 p.m. on Tuesday, April 1; and from 8:00 a.m. to 12:00 noon on Wednesday, April 2. Tickets to all events and information concerning the meeting will be available at this desk. Registration fees for members will be $3 per person. For nonmembers the fee will be $5 per person. Members are encouraged to take advantage of the pre-registration forms which will be sent with the meeting notice. For AIEE Student Members and families of members there will be no fee but registration will be required.

Committees

The members of the South West District Meeting Committee are: R. K. Lane, general chairman; D. W. Allison, vice-chairman; J. H. Heller, secretary; F. N. Wightman, program and meeting papers chairman; G. R. Van Burkleo, program and meeting papers vice-chairman; B. F. Thompson, meeting papers subchairman, industrial applications; C. M. Gordon, Jr., meeting papers subchairman, systems engineering; Dr. R. J. W. Koopman, meeting papers subchairman, engineering education; H. E. Felix, meeting papers subchairman, aircraft; G. A. Smith, meeting papers subchairman, petroleum production; C. A. Burgett, meeting papers subchairman, power transmission; F. J. Meyer, Jr., meeting papers subchairman, power distribution; T. R. Shaw, meeting papers subchairman, petroleum manufacturing; C. L. Moon, meeting papers subchairman, communications; D. K. Holway, meeting papers subchairman, power systems; J. L. Hixon, finance and budget; R. D. Bennett, hotel arrangements; H. A. Norberg, inspection trips chairman; C. W. Brown, inspection trips vice-chairman; H. M. Furtney, registration; D. L. McCausey, publicity chairman; J. C. Wells, entertainment.

PREPRINT PRICES

40¢ to Members
80¢ to Nonmembers

MINIMUM ORDER by mail $1.20 unless accompanied by remittance or coupons. All nonmember orders *must* be accompanied by remittance.

COUPON BOOKS in nine-dollar denominations may be purchased.

NUMBERED PAPERS only are available.

SEND ORDER and remittance to:
AIEE Order Department
33 West 39th Street,
New York 18, N.Y.

Mailed Announcement

A mailed announcement of this meeting will be sent to members in District No. 7. If a copy is desired by members in other Districts please write to E. C. Day, Assistant Secretary for Technical Papers and Programs, TOD, American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N.Y.

The tentative technical program for the District No. 7 Meeting follows.

Monday, March 31

7:45 a.m. Registration—Main Lobby, Mayo Hotel

10:00 a.m. General Session—Crystal Ballroom, Mayo Hotel

Prof. N. F. Rode, vice-president, AIEE District No. 7, will preside

Welcome: The Hon. G. E. Norvell, Mayor City of Tulsa

A Word from the President: W. J. Barrett, National President, AIEE

Keynote Address: "The Electrical Industry and the Southwest," R. K. Lane, chairman of the board, Public Service Company of Oklahoma

12:00 Noon. Joint Luncheon, AIEE and Engineers Club of Tulsa—Chamber of Commerce Building

Address: The Hon. H. M. Milton II, Assistant Secretary of the Army

2:00 p.m. Industrial Applications—Founder's Room, Mayo Hotel

J. H. Heller, Presiding

DP.* **A Planned Large High-Voltage Germanium Rectifier Installation.** *George Choma,* Diamond Alkali Company; *H. N. Hickok,* General Electric Company

DP.* **Electrical Installations in a Modern Cement Plant.** *David LeClair,* Ideal Cement Company

DP.* **Comparative Economics of New Light Sources in Industrial Applications.** *R. D. Bradley,* Day-Brite Lighting, Inc.

2:00 p.m. Systems Engineering—Ivory Room, Mayo Hotel

C. M. Gordon, Jr., Presiding

* District Papers will not be printed by the Institute; however, they may be available at the meeting at the discretion of the author.

DP.* Notes on System Planning. *John Wallis,* Oklahoma Gas & Electric Company

DP.* Southwestern Public Service Company's Use of Digital Computers in Generation Scheduling. *R. W. Thomas,* Southwestern Public Service Company; *J. R. Wilson,* General Electric Company

DP.* Operating Experience with Kansas City Power & Light's Automatic Dispatching System. *W. W. Scott,* Kansas City Power & Light Company

2:00 p.m. Engineering Education—Room "U," Mayo Hotel

Dr. R. J. W. Koopman, Presiding

DP.* Electrical Engineering Education for the Future. *Dr. Pierre Honnell,* Washington University

DP.* Automation and Education. *W. B. Jarzembski,* Jarco Services, Inc.

Tuesday, April 1

9:30 a.m. Aircraft—Room "U," Mayo Hotel

H. E. Felix, Presiding

DP.* High Temperature Construction Materials for Aircraft Electrical Systems. *K. D. McIlwaine,* Westinghouse Electric Corporation

DP.* Qualification Testing of Aircraft Electrical Systems. *T. K. Johnson,* General Electric Company

DP.* Design Considerations for the C-132 Electrical Power Systems. *R. J. Robinson,* Douglas Aircraft Company

9:30 a.m. Petroleum Production—Founder's Room, Mayo Hotel

G. A. Smith, Presiding

DP.* Application of BS&W Monitor in the Petroleum Industry. *K. T. Ball,* Instruments, Inc.

DP.* Power and Control Cables for Oil Industry. *Howard Knox,* Kaiser Aluminum Company Cable Division

DP.* Determining Actual Power Output and Derating Factor of Electric Motors that Drive Oil Well Pumping Units. *Max Halderson,* Phillips Petroleum Company.

9:30 a.m. Power Distribution—Ivory Room, Mayo Hotel

F. J. Meyer, Jr., Presiding

DP.* Modern Use of Reclosures. *Frank McStay,* Line Material Industries

DP.* Over-all Economics Dictates Single-Phase Residential Utilization. *Bela Mohr, Emil Buettner, Bryce Brady,* Oklahoma Gas & Electric Company

DP.* Single-Phase Motors Now Cause Less Flicker in Residences than Three-Phase. *Bryce Brady,* Oklahoma Gas & Electric Company

DP.* Should Fault Current on Distribution Line Be Limited. *G. G. Auer, R. W. Swarthout,* General Electric Company

2:00 p.m. Aircraft—Room "U," Mayo Hotel

M. K. Henry, Presiding

DP.* Electrical Ground Tester for the B-52. *Jimmy Jones,* Boeing Airplane Company

DP.* Aircraft Systems Design for Commercial Airline Maintenance. *J. R. Whitlock,* American Airlines

DP58-450. Switching from Now to the Future. *R. R. Jenner,* Minneapolis-Honeywell Regulator Company

Courtesy Public Service Company of Oklahoma

TULSA POWER STATION, Public Service Company of Oklahoma, viewed at night from across the Arkansas River. A tour of the Tulsa Power Station has been planned as one of the inspection trips to be held during the AIEE South West District Meeting. This station includes a 175,000-kw turbo-generator unit that has been in operation for one year, a second 175,000-kw unit in the final stages of construction, and a 45,000-kw compound unit just completed.

2:00 p.m. Petroleum Manufacturing—Founder's Room, Mayo Hotel

T. R. Shaw, Presiding

DP.* Purchased Electrical Power for the Refinery. *John Mostrom,* Phillips Petroleum Company

DP.* Some Basic Design Considerations for Refinery Electric Power Distribution Systems. *H. O. Hodson, George Dupree,* Southwestern Public Service Company. Paper will be presented by Mr. Hodson

DP.* Requirements for Successful Applications of Data Systems to Processes. *H. S. Stover,* Beckman Instruments Inc.

2:00 p.m. Power Transmission—Ivory Room, Mayo Hotel

C. A. Burgett, Presiding

DP.* Insulator Research for Tomorrow's Lines. *A. D. Lantz,* Ohio Brass Company

DP.* Wood Structures for 230-Kv and 345-Kv Construction. *R. G. Yerk,* Hughes Brothers, Inc.

DP58-449. High Strength Aluminum Alloy Conductors. *E. W. Greenfield,* Kaiser Aluminum & Chemical Corporation

DP.* Narrow Base Steel Towers for Transmission Lines on City Streets. *H. C. Hughes,* San Antonio City Public Service Board

Wednesday, April 2

9:30 a.m. Industrial Applications—Room "U," Mayo Hotel

B. F. Thompson, Presiding

DP.* Motor Operation and Protection on Unbalanced Voltages. *R. S. Reed, G. W. Cunningham,* General Electric Company

DP.* Comparison of Modern Industrial Distribution Transformers. *F. J. Brutt,* Westinghouse Electric Corporation

9:30 a.m. Communications—Founder's Room, Mayo Hotel

C. L. Moon, Presiding

DP.* Transistorizing Radio Equipment. *F. V. Long,* Texas-Eastern Transmission Corporation

DP.* Microwave Systems and Transmission. *A. B. Munson,* Southwestern Bell Telephone Company

DP.* Microwave Reflector Radiation Lobe Study. Motorola; *B. J. Ballard,* Sun Pipe Line Company. Presented by Mr. Ballard

9:30 a.m. Power Systems—Ivory Room, Mayo Hotel

G. I. Page, Presiding

DP58-448. Boiler Protection and Interlocking. *J. L. Barker,* Oklahoma Gas & Electric Company

DP.* The Electrical Industry in Mexico. *A. W. Gelbke,* Ebasco International Company

DP.* The Pump Turbine Story. *F. E. Jaski,* Allis-Chalmers Manufacturing Company

DP.* Pump Turbine Application in Northeast Oklahoma. *D. K. Holway,* W. R. Holway & Associates

2:00 p.m. Substations—Ivory Room, Mayo Hotel

F. P. Kaspar, Presiding

DP.* Economics of Substation Standardization. *T. R. Hoke,* Oklahoma Gas & Electric Company

DP.* Consideration for Remote Data Logging. *W. F. Cruess,* Westinghouse Electric Corporation

DP.* Overload Capability of Modern Power Fuses. *C. H. Baker,* S & C Electric Company

DP.* Progress in Station Class and Intermediate Class Lightning Arresters. *E. J. Allen,* General Electric Company

2:00 p.m. Communications—Founder's Room, Mayo Hotel

S. C. Wright, Presiding

DP.* Guard and Testing Circuit Channel. *W. J. Benton*, Sinclair Pipe Line Company

DP58-452. Microwave Loop System for a Power Utility. *C. C. Anderson*, City of Austin; *E. T. Gray, G. A. Griffith*, Westinghouse Electric Corporation. Presented by Mr. Anderson

DP.* Microwave Station Emergency Power. *W. E. Freese*, Sinclair Pipe Line Company

DP.* Selective Signaling and Control System. *H. J. Michael, W. V. K. Large*, Bell Laboratories. Presented by Mr. Michael

Tentative Technical Program for Nuclear Engineering and Science Conference

THE TENTATIVE PROGRAM of the Nuclear Engineering and Science Conference of the 1958 Nuclear Congress to be held at the International Amphitheatre, Chicago, Ill., March 17-21, follows. This Congress, sponsored by the American Nuclear Society and over 30 national engineering and scientific societies including the AIEE, is the fourth of such meetings. The Congress is co-ordinated by Engineers' Joint Council.

Preprints of papers listed became available on February 3, 1958, and may be obtained by ordering them by number from the Congress Manager, American Institute of Chemical Engineers, 25 W. 45 St., New York 36, N. Y. Use the order coupon printed with the program.

Additional papers are being reviewed at present by sponsoring societies. Preprints of these papers will be on sale at the Amphitheatre.

All papers sell for 50¢ each.

Tentative Program

Session I—Commercial Use of Radioactive Tracers

71* Tracer Studies of Fungicidal Action. *R. W. Greenlee, R. S. Davidson, H. T. Kemp, M. M. Baldwin*

70 Radioactive Tracers in Extreme Pressure Lubrication. *E. H. Loeser, R. C. Wiquist, S. B. Twiss*

75 Location of Leaks with Radioisotopes in Multiwalled Tanks. *W. F. Sullivan*

Session II—Reactor Component Development, Fabrication, and Testing, Part 1

74 Diaphragm Feed Pumps for Homogeneous Reactors. *C. H. Gabbard*

76 High-Temperature Mechanical Canned Motor Liquid Metal Pumps. *O. P. Steele, III*

77 Guide to the Selection of Canned Motor Pumps. *W. M. Wepfer*

Session III—Standardization, Codes, and Licensing

78 A Review of Structural Evaluation Procedures. *W. E. Cooper*

79 Code Problems in the Design of Nuclear Power Plants. *John Zickel*

132 Inspection and Testing of Pressure Piping as Related to Nuclear Power Plants. *V. T. Malcolm, Sidney Low*

Session IV—Reactors for Process Heat and Radiation

162 The Chlorination of Mesitylene and Naphthalene in the Presence of Gamma Radiation. *W. M. Sergy, J. F. Hanus, J. Oishi, J. J. Martin, L. C. Anderson*

Session V—Production and Miscellaneous Application of Radioisotopes

45 The Release of Strain in Prince Rupert's Drops by Gamma Irradiation. *C. H. Greene*

60 The Use of Tritium as an Ionizing Source in Instruments. *G. F. Vanderschmidt, J. R. Roehrig, J. C. Simons, Jr.*

48 The Effect of Nuclear Radiation on the Behavior of Cellulose and Cellulose Derivatives. *Otto Teszler, H. A. Rutherford*

135 Density Measurement of Saturated Submersed Sediment by Gamma Ray Scattering. *L. O. Timblin, Jr.*

136 Kilocurie Production of Barium-140. *B. M. Legler, A. L. Ayers*

Session VI—Reactor Component Development, Fabrication, and Testing, Part 2

30 Control Rod Drive Mechanism for the Argonne Low-Power Reactor. *W. J. Kann*

167 Development of a Welded Seal for a Reactor Vessel Head. *K. B. Garner, J. W. Rogers*

80 Control Rod Drive Mechanisms for Hermetically Sealed Pressurized Light-Water Nuclear Power Reactor. *J. J. Gertz, J. W. Flaherty*

149 Control Valves for the Homogeneous Reactor Test. *A. M. Billings*

Session VII—Reactor Operation and Maintenance, Part 1

81 Start-up and Operation of the Sodium Reactor Experiment. *L. E. Glasgow*

82 Direct Maintenance Practices for the Homogeneous Reactor Test. *S. E. Beall, R. W. Jurgensen*

83 Testing Required for Full-Power Operation at Shippingport Atomic Power Station. *S. G. Schaffer*

Session VIII—Fuel, Control, Moderator, and Coolant Materials, Part 1

13 Comparison of the Active with the Inactive Uranium Dioxide-Oxygen System. *D. A. Vaughan, R. K. Willardson*

19 Metallurgical Design and Properties of Silver-Indium-Cadmium Alloys for PWR Control Rods. *I. Cohen, E. F. Losco, J. D. Eichenberg*

18 Effects of Pile-Irradiation on UaSi. *M. L. Bleiberg, L. J. Jones*

23 Radiolytic and Pyrolytic Decomposition of Organic Reactor Coolants. *D. R. de Halas*

20 Some Aspects of the Use of an Organic Coolant in a Heavy-Water Moderated Power Reactor. *M. J. McNelly*

Session IX—Fuel, Control, Moderator, and Coolant Materials, Part 2

17 The Effects of Transformation Cooling Rate on the Activation Energy Required for Recrystallization of Beta-Quenched Uranium. *H. R. Gardner, J. W. Riches*

63 Electron Metallography of the U-Ni Diffusion Zones. *C. L. Angerman*

84 The Corrosion Behavior of Uranium-Zirconium Alloys in High-Temperature Water and Steam. *S. Kass, K. M. Goldman, D. E. Thomas*

85 The Effect of Carbon on the Transformation of Uranium-Niobium Alloys. *H. Maier, J. Hino, J. J. Lombardo*

86 Corrosion Behavior of Uranium-Niobium Alloys in High-Temperature Water. *J. N. Chirigos, J. Hino, J. J. Lombardo*

87 Transformation Kinetics of Uranium-Niobium and Uranium-Niobium-Silicon. *F. C. Holtz, R. J. van Thyne*

133 High-Temperature Fatigue Testing—With Application to Uranium. *J. R. Bohn, Glenn Murphy*

Session X—Reactor Operation and Maintenance, Part 2

68 Chemical Operating Experience at the Army Package Power Reactor. *A. L. Medin, W. S. Brown*

88 Proposed Fuel Handling Facilities. *H. J. Bellaris*

89 Nuclear Power Plant Operator Training. *Robert Enstice, R. L. Gardner*

90 Planning for the Start-up of the Dresden Nuclear Power Station. *K. T. Perkins, H. K. Hoyt*

91 Ion Exchange Removal of Fission Products from High-Purity Water. Laboratory Development Work Associated with the PWR Radioactive Waste Disposal System. *W. T. Lindsay, Jr., C. S. Abrams, J. A. LaPointe*

92 Long-Lived Circulating Activity at APPR-1. *W. J. Small*

130 Water Treatment Process for the Dresden Nuclear Power Station. *H. D. Ongman*

Session XI—Experimental Power Reactors and Advanced Concepts, Part 1

93 Direct Cycle Reactors for ANP. *T. Szekely*

Session XII—Health Physics and Instrumentation

4 Application of Pulse Height Analysis to Health Physics Problems. *A. B. Carlson, E. L. Geiger*

49 Trends in Radiation Protection with Nuclear Reactors. *W. H. Truran*

94 Recent Developments in Personnel Radiation Dosimetry. *J. J. Fitzgerald, R. J. Feinberg*

Session XIII—Reactor Physics

51 A Magnetic Beam Focusing and Analyzing System for Cyclotrons. *K. L. Boring, R. F. Edgar, L. H. Stauffer*

95 The Role of Accelerators in Reactor Research. *E. A. Burrill*

96 Nuclear Physics and Core Design for the Merchant Ship Reactor. *P. M. Wood*

97 Nuclear Design of Aircraft Reactors. *D. S. Selengut*

*Preprint Order Number

124 **Full-Scale Turbojet Activation Experiment.** *J. Moteff*

125 **Nuclear Problems Associated with the Plutonium Recycle and with the Experimental Reactor.** *J. R. Trippiett*

126 **Physics of Reactor for the Irradiation of Bulky Materials and Equipment.** *D. L. Fischer, M. L. Weiss, B. Wolfe*

134 **Comparison of Experimentally Determined Fission Rates with Calculated Values in Small Diameter Fuel Pins.** *G. D. Calkins, R. H. Barnes, D. N. Sunderman, E. M. Chandler, M. Pobereskin*

Session XIV—Experimental Power Reactors and Advanced Concepts, Part 2

33 **Control System on a Turbine-Generator Supplying Commercial Power as a By-Product of a Nuclear Test Reactor.** *H. W. Bassett, Jr., E. R. Gasser*

98 **Performance and Potential of Natural Circulation Boiling Reactors** *S. W. Flinn, M. Petrick*

99 **An Evaporatively Cooled Reactor.** *G. Leppert, W. G. Camack*

100 **The Armour Dust Fueled Reactor (ADFR).** *D. Krucoff*

Session XV—Temperature Measurements and High-Temperature Instrumentation

56 **A High-Temperature Fission Chamber.** *J. B. Ruble, S. H. Hanauer*

123 **Neutron Detector for High-Temperature Applications.** *E. B. Sehr*

151 **Temperature Measurement in French Reactors.** *J. Weill*

157 **High-Temperature Pressure Measurement.** *R. J. Ingham, R. C. DuBois*

158 **Temperature Measurements in High Flux Regions of a Reactor.** *W. N. Craigue*

159 **Research on Thermocouples To Establish Sustained Accuracy of Temperature Measurement to 2,000 F.** *J. F. Potts, Jr.*

Session XVI—Waste Treatment and Disposal

14 **Geological and Hydrologic Guides to the Ground Containment and Control of Wastes at Hanford.** *R. E. Brown, W. H. Bierschenk*

44 **Characteristics of Reactor Fuel Process Wastes.** *J. O. Blomeke, E. D. Arnold, A. T. Gresky*

67 **The Behavior of Ruthenium in the Fixation of Fission Products.** *W. E. Erlebach, R. W. Durham*

1 **Studies on Characteristics of Savannah River Wastes.** *B. Manowitz, C. W. Pierce, S. Zwicker*

55 **Treatment of Radioactive Wastes Using Ion Transfer Membranes: Removal of Bulk Electrolytes.** *E. A. Mason, E. J. Parsi, A. J. Giuffrida*

101 **Special Considerations in the Design of the Waste Disposal Plant for the Shippingport Reactor.** *J. R. LaPointe, J. V. A. Longcour, W. R. Kennedy, W. T. Lindsay, Jr.*

102 **Radioactive Liquid Waste Disposal from the Dresden Nuclear Power Station.** *C. F. Falk*

141 **Treatment of Liquid Radioactive Wastes —European Practice.** *C. P. Straub*

Session XVII—Reactor Plant Instrumentation

6 **Measurement of Primary Water Flow.** *D. E. Collins*

5 **Instrumentation Experience with 2,000 PSI 600 F Slurry Test Loops for PAR Homogeneous Reactor Project.** *E. A. Goldsmith, W. W. Wenzel*

36 **An Electronic Feedwater Control System for the Experimental Boiling Water Reactor.** *R. H. Morse, R. N. Brey, Jr.*

34 **A New Method for the Measurement of Gases in High Pressure Water Reactor Plants.** *F. C. Steiner*

103 **Control Systems for Boiling Water Power Reactors.** *R. N. Brey, Jr.*

163 **Steam Generator Instrumentation for a Nuclear Power Plant with Analog Computer Verification of Dynamic Action.** *E. E. Lynch, D. P. Waite*

Session XVIII—Fuel, Control, Moderator, and Coolant Materials, Part 3

16 **Cement Control Rod Fabrication by Powder Rolling.** *Samuel Storchheim*

2 **Blending vs Re-Enrichment for Slightly Enriched Uranium.** *Donald Kallman, J. E. Brennan*

40 **Effects of Uranium Ore Refinery Wastes on Receving Waters.** *E. C. Tsivoglou, A. F. Bartsch, D. E. Rushing, D. A. Holaday*

43 **LMFR Breeder Blanket Preparation by Fusion Electrolysis.** *M. E. Sibert, A. L. Cunningham, M. A. Steinberg*

62 **Melting and Fabrication of a Silver Base Alloy for Control Use in Nuclear Reactors.** *R. J. Hafleman, W. B. Haynes, R. W. Tombaugh*

65 **Preparation and Properties of Uranium Dioxide Powder.** *C. D. Harrington, A. E. Ruehle*

104 **Dispersed Boron Control Rods.** *S. J. Paprocki, G. Cunningham*

Session XIX—Reactor Location and Safety

15 **Physical Factors in the Gainesville, Fla., Area Affecting Site Location of a One Megawatt Nuclear Research Reactor.** *S. O. Reichert*

46 **Analysis of the Plutonium Recycle Program Reactor Hazards.** *N. G. Wiltenbrock*

105 **The Scope and Philosophy of Nuclear Power Plant Testing.** *E. E. Lindahl*

106 **Health Physics for an Urban Nuclear Facility.** *J. W. Baum*

148 **Design of Nuclear Laboratories.** *D. I. Weinberg*

Session XX—Thermal and Mechanical Design, Part 1

107 **Core Thermal Design of Army Package Power Reactor-LA.** *J. O. Brondel*

108 **An Electrolytic Analog for Reactor Heat Transfer Problems.** *Paul Anthony, G. Friedensohn*

145 **Heat Transfer Characteristics of Polyphenyl Reactor Coolants.** *M. Silberberg, D. A. Huber*

27 **Free Convection Heat Transfer to Water and Mercury in an Enclosed Cylindrical Tube.** *J. P. Hartnett, W. E. Welsh, Jr., F. W. Larsen*

144 **The Effect of a Volume Heat Source on Free Convection Heat Transfer.** *I. E. Randall, Alexander Sesonske*

Session XXI—Reactor Control Instrumentation, Part 1

42 **Consideration in the Design of the Nuclear Safety Instrumentation System for the Enrico**

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31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135
136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165
166	167													

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Fermi Atomic Power Plant. *V. S. Underkoffler, R. G. Olson*

32 Instrumentation for a Boiling Water Reactor. *Lester Kornblith, Jr.*

53 Nuclear Power Plant Transfer Functions. *H. B. Smets, E. P. Gyftopoulos*

50 Modular Concepts in Reactor Control Instrumentation. *J. L. Cockrell, D. F. Ryan, J. H. Magee*

152 French System Control Instrumentation. *J. Weill*

Session XXII—Progress in Commercial Power Reactor Development

60 Design of the Power Plant for the First Nuclear Merchant Ship. *R. L. Whitelaw*

127 Developments in Commercial Atomic Power Plants. *G. H. Farbman*

131 The Consolidated Edison Nuclear Electric Generating Station. *O. G. Hanson, F. R. Ward*

Session XXIII—Reactor Plant Materials, Part 1

24 Corrosion Screening of Component Materials for NaK Heat Exchange Systems. *S. J. Basham, J. H. Stang, E. M. Simons*

109 Dynamic Corrosion Tests of Materials in Irradiated Organics. *H. Kline*

110 Hydrogen Pickups in Zircaloy-2 during Corrosion in High Temperature Water and Steam. *S. Kass, K. M. Goldman, D. E. Thomas*

Session XXIV—Thermal and Mechanical Design, Part 2

146 Boiling Pressure Drop in Thin Rectangular Channels. *N. C. Sher, S. J. Green*

147 Two-Phase Steam Water Pressure Drops. *H. S. Isbin, R. H. Moen, R. O. Wickey, D. R. Mosher, H. C. Larson*

Session XXV—Reactor Control Instrumentation, Part 2

3 Nuclear Reactor Fission Product Monitors. *J. Kohl*

111 Controls for Aircraft Nuclear Reactors. *G. E. Gorker*

Session XXVI—Reactor Plant Materials, Part 2

37 Radiation Damage Studies of Seven Nonfissionable Metals. *C. A. Bruch, W. E. McHugh*

Session XXVII—Nuclear Education and Training

164 Relationships between the Universities and Industry in Nuclear Engineering. *Glenn Murphy*

165 Relation between Industry and Government. *W. K. Davis*

166 Nuclear Training Programs for Industry Personnel. *S. J. Harris*

Session XXVIII—Fuel Element Development, Fabrication, and Testing, Part 1

38 The Fabrication of Stainless Steel-UO_2 Fuel Plates. *W. R. Weinberger, H. S. Kalish*

Session XXIX—Reactor Safety and Start-Up Instrumentation

41 Variation of the Trip Point in the ORNL Type Safety System. *J. L. Cockrell, C. W. Ricker*

35 Transistor Count Rate Systems. *L. E. Weisner*

154 Radiation Damage to BF_3 Proportional Counters. *R. C. Wils*

156 A Counting Channel Pulse Transmission Circuit. *J. Parnell*

Session XXX—Reactor Systems Analysis, Part 1

58 Application of Root-Locus Analysis to Nuclear Reactor Systems. *E. H. Lemon*

59 The Use of Signal-Flow Graphs in Kinetic Analysis of Nuclear Reactors. *A. B. Van Rennes*

54 A Digital Program to Evaluate Transients for Nuclear Power Plant Design. *F. J. Scheib, A. J. Arker*

112 Variable Transport Lag Simulation. *E. G. Holzmann*

138 Control of the PRPR—A Gas Balance Method with Supplementary Mechanical Shims. *J. F. Fletcher*

153 Some New Techniques in Nuclear Power Plant Simulation. *J. Weill*

Session XXXI—Fuel Element Development, Fabrication, and Testing, Part 2

113 Diffusion Zone Growth of Zircaloy Clad U-Nb Fuel Elements. *R. M. Stackhouse, J. E. McCauley, H. W. Young*

114 Gas Pressure Bonding of Fuel Assemblies. *Stan Paprocki*

115 Forge Rolling Fuel Element and Cover Plates. *R. D. Johnson, R. J. Gridley, R. L. Clark*

116 Fuel Irradiation Test Facilities. *R. J. Schlitz, D. R. Patterson*

Buffalo, Birthplace of Power, Will Be Site of AIEE Summer General Meeting

CENTER CITY AREA of Buffalo, N. Y. (above, *left*), where the AIEE Summer General Meeting will be held June 22-27, 1958. The Air Transportation Conference will be held in conjunction with this meeting. Above, *right*: Chairmen of standing committees for the Summer General Meeting and members of the AIEE Niagara Frontier Section at a recent meeting include: (*seated, left to right*) E. J. Rahill, program chairman; L. J. Murphy, treasurer; D. J. Munhall, general chairman; B. S. Rice, vice-chairman and secretary; Clarence Lynn, hospitality chairman; W. F. Reuber, finance chairman; (*standing, left to right*) K. J. Kelly, public relations co-chairman; R. A. Beuerman, inspection trips chairman; C. J. Brumbaugh, printing chairman; W. K. Parks, hotel reservations and accommodations chairman; J. P. Wood, technical papers chairman; W. N. Carlson, meetings and properties chairman; M. O. Johnson, air transportation chairman; C. H. Sullivan, Jr., transportation chairman; T. J. Brosnan, president's reception and banquet chairman; E. V. Ellett, entertainment committee; E. D. Lynch, Jr., entertainment committee; C. E. Gaylord, luncheons and dinners chairman; G. W. Eighmy, registration chairman. Other officers not shown in the photo are W. J. Thompson, publicity co-chairman; Mr. and Mrs. E. F. Sigmund, ladies program co-chairmen; H. B. Vidal, entertainment chairman; C. W. King, special projects chairman; and C. M. Fogel, student affairs chairman.

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AIEE Future Meetings

Textile Conference*
Georgia Institute of Technology
Atlanta, Ga.
March 13-14, 1958

EJC Nuclear Congress*
International Amphitheatre
Chicago, Ill.
March 17-21, 1958

AIEE-ASME Engineering Management Conference*
Hotel Somerset
Boston, Mass.
March 19-20, 1958

American Power Conference*
Sherman Hotel
Chicago, Ill
March 26-28, 1958

Pulp and Paper Conference*
North Carolina State College
Raleigh, N. C.
March 27-29, 1958

South West District Meeting*
Mayo Hotel
Tulsa, Okla.
March 31-April 2, 1958

AIEE-ASME-IRE-ISA-AIChE Automatic Optimization Conference*
University of Delaware
Newark, Del.
April 2-4, 1958

AIEE-ASME Railroad Conference*
Statler Hotel
Cleveland, Ohio
April 9-10, 1958

Rubber and Plastics Conference*
Mayflower Hotel
Akron, Ohio
April 14-15, 1958

AIEE-IRE-ASME Automatic Techniques Conference (Automation and Data Processing)*
Statler Hotel
Detroit, Mich.
April 14-16, 1958

AIEE-IRE-EIA-WCEMA Joint Electronic Components Conference*
Ambassador Hotel
Los Angeles, Calif.
April 22-24, 1958

Middle Eastern District Meeting*
Sheraton-Park Hotel
Washington, D.C.
April 28-30, 1958

Great Lakes District Meeting*
Michigan State University
East Lansing, Mich.
May 5-7, 1958

AIEE-IRE-ACM Western Joint Computer Conference (Exhibit)*
Ambassador Hotel
Los Angeles, Calif.
May 6-9, 1958

East Central District Meeting
Prichard Hotel
Huntington, W. Va.
May 13-15, 1958
(Final date for †TP—closed, DPMs —March 11)

Vermont Subsection-U of Vermont Power System and Computer Symposium
University of Vermont
Burlington, Vt.
May 15-16, 1958

Materials Handling Conference
Pittsburgh, Pa.
May 19-20, 1958
(Final date for †TP—closed, ‡CP Syn.—March 4, CPMs—March 14)

Appliance Technical Conference
Hotel Morrison
Chicago, Ill.
May 26-27, 1958
(Final date for †TP—closed, ‡CP Syn.—March 11, CPMs—March 21)

AIEE-ISA-IAS-ARS National Telemetering Conference (Exhibit)
Lord Baltimore Hotel
Baltimore, Md.
June 2-4, 1958
(Final date for †TP—closed, ‡CP Syn.—March 18, CPMs—March 28)

Summer General Meeting
Hotel Statler
Buffalo, N. Y.
June 22-27, 1958
(Final date for †TP—March 14, ‡CP Syn.—April 3, CPMs—April 7)

AIEE-IRE Nonlinear Magnetics and Magnetic Amplifiers Conference (Exhibit)
Statler Hotel
Los Angeles, Calif.
August 5-8, 1958
(Final date for †TP—April 25, ‡CP Syn.—May 20, CPMs—May 30)

AIEE-IRE-NBS Electrical and Radio Standards Conference
University of Colorado and NBS
Boulder, Colo.
August 13-15, 1958
(Final date for †TP—May 5, ‡CP Syn.—May 30, CPMs—June 9)

Pacific General Meeting
Hotel Senator
Sacramento, Calif.
August 19-22, 1958
(Final date for †TP—May 9, ‡CP Syn.—June 3, CPMs—June 6)

Petroleum Industry Conference
Baker Hotel
Dallas, Texas
September 15-17, 1958
(Final date for †TP—June 6, ‡CP Syn.—July 1, CPMs—July 11)

Power Industry Computer Application Conference
Toronto, Ont., Canada
September 15-17, 1958
(Final date for †TP—June 6, ‡CP Syn.—July 1, CPMs—July 11)

AIEE-IRE Industrial Electronics Conference
Detroit, Mich.
September 24-25, 1958
(Final date for †TP—June 16, ‡CP Syn.—July 11, CPMs—July 21)

AIEE-IRE-ASME National Power Conference
Statler Hotel
Boston, Mass.
September 28-October 1, 1958
(Final date for †TP—June 20, ‡CP Syn.—July 15, CPMs—July 25)

AIEE-IRE-EIA-SMPTE National Electronics Conference
Hotel Sherman
Chicago, Ill.
October 13-15, 1958
(Final date for †TP—July 4, ‡CP Syn.—July 29, CPMs—Aug. 8)

Machine Tools Conference
Statler Hotel
Hartford, Conn.
October 13-15, 1958
(Final date for †TP—July 4, ‡CP Syn.—July 29, CPMs—Aug. 8)

Fall General Meeting
Sheraton Hotel
Pittsburgh, Pa.
October 26-31, 1958
(Final date for †TP—June 27, ‡CP Syn.—Aug. 4, CPMs—Aug. 8)

AIEE-IRE-ACM Eastern Joint Computer Conference (Exhibit)
Bellevue-Stratford Hotel
Philadelphia, Pa.
December 3-5, 1958
(Final date for †TP—Aug. 25, ‡CP Syn.—Sept. 19, CPMs—Sept. 29)

Winter General Meeting
New York, N. Y.
February 1-6, 1959
(Final date for †TP—Oct. 14, ‡CP Syn.—Nov. 5, CPMs—Nov. 7)

South East-South Central District Meeting
Atlanta, Ga.
April 8-10, 1959
(Final date for †TP—Dec. 27, DPMs —Jan. 12)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

129 Model Studies of the Flow Characteristics of the Fuel Elements for the Enrico Fermi Reactor. *W. N. McDaniel, O. E. Homeister, R. A. Yagle*

140 A Study of the Feasibility of a Tracer System for Locating—A Fuel-Element Failure in a Pressurized Water Reactor. *Meyer Pobereskin, D. N. Sunderman, Aaron Eldridge, G. D. Calkins, Walston Chubb*

Session XXXII—Research and Test Reactors and Critical Assemblies

29 Nuclear Safety Considerations in the Handling and Storage of Reactor Fuels. *Norman Ketzlach*

57 Design and Description of an Enriched Uranium Neutron Flux Converter. *R. Anlioi, R. Uyetani, R. D. Shelton, A. R. Rana*

117 Problems in the Mechanical Design of SPERT Experimental Reactors. *T. R. Wilson, W. M. Hawkins*

118 High Power Intermediate Enrichment Pool Reactor. *J. Jacobson, W. S. Prince, R. O. Niemi*

Session XXXIII—Reactor Systems Analysis, Part 2

52 Parallel Operation of Reactor Plants. *A. C. Sanderson, R. M. Strong*

128 Model Studies of Coolant Flow in the PWR Reactor. *F. A. Grochowski, H. R. Hazard, J. Sherman, S. J. Flanigan*

137 Coolant Temperature Rise in a Pressurized Water Reactor during a Loss of Flow Incident. *J. Weisman, S. Bartnoff, G. G. Tirellis*

150 Power Driven Rod Insertion for Reactor Protection. *J. E. Stell, E. E. Schiring*

Session XXXIV—Chemical Reprocessing, Part 1

21 Pilot Plant Fluorination of Uranium Fuel Elements by Bromine Trifluoride. *G. Strickland, F. L. Horn, R. Johnson*

26 Auxiliary Equipment for Radiochemical Processing. *W. E. Unger*

39 Mechanical Disassembly of Spent Power-Reactor Fuels. *W. W. Barton, J. J. Brooks*

28 Flow Generation, Measurement, and Control. *J. Dunn, H. M. Jones*

160 An On-Stream Monitor for Alpha Activity. *N. T. Hildreth*

161 The Advantages of Continuous Analyzers in a Pilot Plant. *C. L. Pleasance*

Session XXXV—Water Contamination and Treatment

10 Studies of Radioactivity in the Chicago Water Supply. *J. C. Vaughn, R. W. Schmidt, Alfred Tenny, Arthur Shor*

11 The Adsorption of Radioactive Substances on Waterborne and Consolidated Materials. *F. B. Barker*

47 Cross Connections: Their Prevention and Control in the Y-12 Plant of Union Carbide Nuclear Company at Oak Ridge, Tenn. *G. J. Angele*

64 A Field Test of the Movement of Radioactive Cations through an Underground Formation. *B. B. Ewing*

72 Radionuclides in Reactor Cooling Water—Identification, Source, and Control. *D. W. Moeller, G. W. Leddicotte, S. A. Reynolds*

142 Laboratory Chemical Coagulation Studies on the Removal of Fallout Radioactivity in Waters. *L. R. Setter, H. H. Russell*

148 The Use of the Gamma Spectrometer for the Identification of Radionuclides in Water. *G. R. Hagee, A. S. Goldin, C. P. Straub*

155 The Sensitivity of Counters for Measuring the Beta Activity of Water. *G. R. Hagee, A. S. Goldin, L. R. Setter*

Session XXXVI—Reactor Shielding and Containment

9 Thermal Considerations in the Design of Concrete Structures for Shielding Atomic Power Plants. *H. S. Davis*

61 Civil Engineering Aspects of the Dresden Nuclear Power Station. *J. E. Love, C. S. Darrow, B. H. Randolph*

119 Reactor Shield Calculations. *W. E. Edwards*

120 Shielding for Aircraft Nuclear Reactors. *F. A. Aschenbrenner*

73 Design of ERR-II Primary Tank Support Structure. *R. W. Seidensticker, S. H. Fistedis*

121 Containment-Vessel Design Basis for the Dresden Nuclear Power Station. *G. Sege*

Session XXXVII—Chemical Processing, Part 2

8 The Nitrate Complexes of Tetravalent Plutonium. *J. A. Brothers, R. G. Hart, W. G. Mathers*

7 The Homogeneous Reactor Test Chemical Processing Plant. *W. D. Burch*

22 General Economics of Chemical Reprocessing Using Solvent Extraction Processing. *F. L. Culler, Jr.*

25 Effect of Geometrical Shape on the Continuous Dissolution of Aluminum in Mercury—Catalyzed Nitric Acid. *A. F. Boeglin, J. A. Buckham*

66 Reprocessing Costs for Fuel from a Single-Region Aqueous Homogeneous Reactor. *A. C. Jealous, R. J. Klotzbach*

122 Thorex Short Cooled Processing. *A. B. Meservey*

139 Reprocessing Uranium-Zirconium Alloy Reactor Fuel Elements. *C. B. Leak, R. B. Lemon, F. K. Wrigley*

20th Anniversary Meeting of the American Power Conference

THE AMERICAN POWER CONFERENCE, sponsored by Illinois Institute of Technology in co-operation with 13 universities and 10 local and national engineering societies, including the AIEE, will be held March 26-28, 1958, at the Sherman Hotel in Chicago, Ill.

The purpose of the Conference is to provide a forum for the exchange of information in the fields of power generation, transmission, distribution, and utilization.

All interested persons are cordially invited to attend. Registration information may be obtained from Dr. E. R. Whitehead, Secretary, American Power Conference, Illinois Institute of Technology, Chicago 16, Ill.

The tentative technical program for the conference follows.

Wednesday, March 26

9:00 a.m. Registration—Mezzanine Floor, Sherman Hotel

10:00 a.m. Opening Meeting—Grand Ballroom

Public Affairs—A New Dimension for Management. *F. R. Barnett*, The Richardson Foundation, Inc.

The Road Ahead. *C. L. Wilson*, dean, University of Missouri School of Mines and Metallurgy

12:15 p.m. Joint APC-ASME Luncheon—Bernard Shaw Room. Sponsored by The American Society of Mechanical Engineers (ASME)

Chairman: *J. N. Landis*, president, ASME

Co-Chairman: *E. P. Berg*, chairman, Chicago Section ASME

Speaker: *J. W. McAfee*, president, Edison Electric Institute, and president, Union Electric Company of Missouri

2:00 p.m. Steam Turbines—Grand Ballroom. Sponsored by Power Division of ASME

Chairman: *W. E. Hopkins*, chairman, Power Division ASME, Stone & Webster Engineering Corporation

Co-Chairman: *R. C. Porter*, University of Michigan

Steam Turbines for Nuclear Power Plants. *J. A. Carlson*, Westinghouse Electric Corporation

High-Temperature Steam Turbine Design Improvements from Operating Experience. *E. P. Hansen, A. C. Holmes, J. J. Fleischmann*, Allis-Chalmers Manufacturing Company

Turbine Generators for the '60's. *C. E. Kilbourne, C. W. Elston*, General Electric Company (GE)

2:00 p.m. Symposium on Scheduling and Billing of Economy Interchange on Interconnected Power Systems

Chairman: *Nathan Cohn*, Leeds & Northrup Company

Co-Chairman: *M. S. Helm*, University of Illinois

CP58-496 Practices on the Single Area Pennsylvania–New Jersey–Maryland Interconnection. *H. W. Phillips*, Pennsylvania–New Jersey–Maryland Interconnection

CP58-497 Practices on the Multiple Area North-Eastern Interconnection. *W. D. Wilder*, Niagara Mohawk Power Corporation

CP58-498 Practices on the AGE System. *A. H. Willennar*, American Gas & Electric (AGE) Service Corporation

CP58-499 Practices on the United Pool. *E. K. Corporon*, Interchange Power Services, Inc.

2:00 p.m. Water Technology I, Panel Discussion on Deaeration—Assembly Room

2:00 p.m. Heating, Ventilation, and Air Conditioning—Crystal Room. Sponsored by the Heating and Air Conditioning Division, Chicago Section ASME

Chairman: *E. P. Berg*, chairman, Chicago Section ASME

Co-Chairman: *H. J. Holloman*, Ragnar Benson, Inc., Engineers and Builders

Ventilation of Research Nuclear Reactors. *John Dolio*, Shaw, Metz and Dolio, Architects and Engineers

The Multistage Heat Pump and Its Applications. *R. G. Werden*, York Corporation

Central Station Ventilation. *R. W. Patterson*, Sargent & Lundy, Engineers

Off-Peak Electric Panel Heating Using the Heat Storage Principle. *R. C. Geyer*, Commonwealth Edison Company

7:30 p.m. Evening Forum—Grand Ballroom

A progress report on nuclear developments in the electric power industry. Executives of electric utility companies will describe the current status of the various nuclear reactor projects in which their companies are participating, and discuss plans for future research and development.

Thursday, March 27

9:00 a.m. Central Stations I—Grand Ballroom

Co-Chairman: *H. L. Solberg*, School of Mechanical Engineering, Purdue University

Operating Experience with the First Commercial Supercritical Pressure Steam–Electric Generating Unit at the Philo Plant. *T. T. Frankenberg, A. G. Lloyd, E. B. Morris*, AGE Service Corporation

Operating Experience with the First Commercial Universal Pressure Steam Generator at Philo. *J. D. Andrews, Jr., P. H. Koch, E. A. Pirsh*, E. A. Babcock & Wilcox Company

Operating Experience with the First Commercial Supercritical Pressure Steam Turbine Built for the Philo Plant. *R. Sheppard*, GE

9:00 a.m. Extrahigh Voltage Systems—Louis XVI Room

Co-Chairman: *E. T. B. Gross*, Illinois Institute of Technology

The Commonwealth Edison Company 345-Kv Interconnection with AGE. *L. F. Lischer*, Commonwealth Edison Company

The German 400-Kv System. *W. Fleischer*, Deutsche Verbundgesellschaft e.V., Heidelberg, West Germany

Lightning Performance of High-Voltage Transmission Lines. *J. H. Hagenguth*, GE

9:00 a.m. Fuels—Assembly Room Sponsored by the Fuels Division of ASME

9:00 a.m. Hydroelectric Power I, Symposium on Pumped Storage—Crystal Room

Pumped Storage Economics. *G. R. Rich*, Charles T. Main, Inc., and Uhl, Hall and Rich

Planning for Pumped Storage. *E. S. Loane*, General Public Utilities Corporation

Application of Pumped Storage Hydro to Midwestern Terrain. *G. J. Vencill*, Union Electric Company

Operating Experiences with Large Pumps at Grand Coulee Dam. *G. R. Barker*, Columbia Basin Project, U. S. Bureau of Reclamation

12:15 p.m. Joint APC–AIEE Luncheon—Bernard Shaw Room. Sponsored by AIEE

Chairman: *W. J. Barrett*, president, AIEE

Co-Chairman: *E. G. Norell*, chairman, Chicago Section AIEE

Speaker: *Major General C. G. Holle*, Department of the Army, Office of the Chief of Engineers, Washington, D. C.

2:00 p.m. Central Stations II—Grand Ballroom

Chairman: *J. A. Carlson*, Westinghouse Electric Corporation (Westinghouse)

Co-Chairman: *G. F. Markley*, chairman, Power Section, Chicago Section ASME

How To Reduce the Hazard of Inoperative Check Valves. *L. H. Carr*, Edward Valves Inc., Subsidiary, Rockwell Manufacturing Company

The Turbo-Furnace for Multifuel Firing. *C. F. Hawley*, Riley Stoker Corporation

From Boiler Boil-Out to Operating Date. *J. A. Donald, C. D. Blanke, N. A. Miller*, Sargent & Lundy

Vulnerability of a Central Station Power Plant to Attack by a Nuclear Weapon. *D. B. Singer*, Armour Research Foundation (ARF)

2:00 p.m. Transformers—Louis XVI Room

Chairman: *W. M. Joslin*, Commonwealth Edison Company

Co-Chairman: *E. L. Nicolson*, GE

CP58-494 Power Transformer Applications. *C. L. Rose*, Bureau of Reclamation, Denver Federal Center

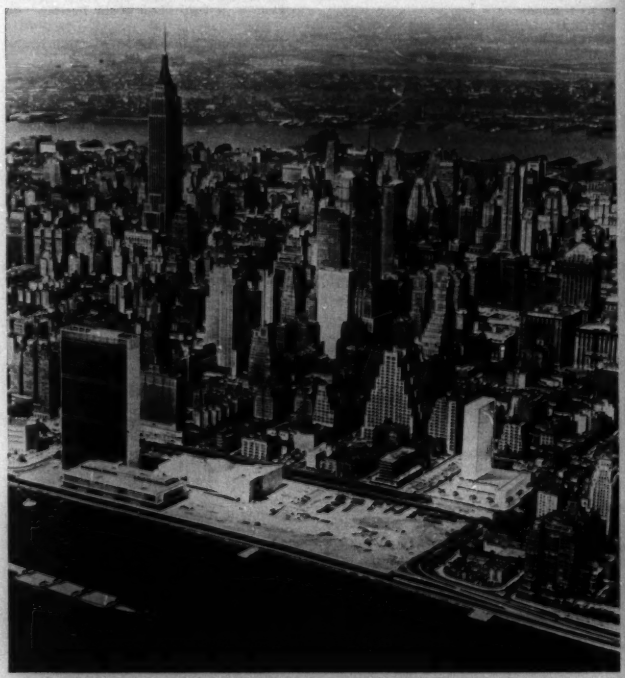
Power Transformers with Reduced Bil. *F. J. Vogel*, Allis-Chalmers Manufacturing Company (A-C)

Millions Saved by Utilizing Increased Transformer Capabilities. *K. J. Falck*, Philadelphia Electric Company

Dual Voltage Distribution Transformers. *R. D. Nelson*, R T & E Corporation

2:00 p.m. Water Technology II, Ion Exchange—Assembly Room

United Engineering Center Site



AERIAL VIEW of the new United Engineering Center—light colored structure shown at lower right opposite the right-hand end of United Nations Park. The 20-story tower will face on 47th St. Lower left is the UN Building; upper left, the Empire State Building; direct center, the Chrysler Building (with spire). Accessibility of new Center to members is illustrated by the fact that (1) the East Side airlines terminal is just to the left of the UN Building, (2) Grand Central Station is just behind the Chrysler Building, and (3) Pennsylvania Station is just behind the Empire State Building. Demolition of old buildings on the 47th–48th St. and UN Plaza site has started. Present plans call for groundbreaking in the Summer of 1958.

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

2:00 p.m. Hydroelectric Power II—Louis XVI Room

Hells Canyon in Retrospect. *T. E. Roach*, Idaho Power Company

Engineering Plan and Design for Effective Water Utilization at Brownlee, Oxbow, and Hells Canyon. *R. E. Gale*, Idaho Power Company

Construction Progress at Brownlee and Oxbow

6:45 p.m. All Engineers Dinner—Grand Ballroom

Friday, March 28

9:00 a.m. Gas Turbines—Louis XVI Room

A Gas Turbine in the Industrial Steam Power Cycle. *J. E. Parker*, Union Carbide Chemicals Company

How to Integrate Gas Turbines with other Generation in an Economical Utility Generating System. *W. D. Marsh*, GE.

Gas Turbines as an Economic Generating Source. *W. H. Ferguson, R. E. Strong*, Westinghouse Electric Corporation

9:00 a.m. Water Technology III, Nuclear Power—Assembly Room

9:00 a.m. Distribution Equipment—Crystal Room

Chairman: *H. P. St. Clair*, AGE Service Corporation

Co-Chairman: *J. N. Banky*, Allis-Chalmers

Substation Application of Reclosers. *F. W. McStay*, Kyle Switchgear, Line Material Industries

Application of Vacuum Switches to Utility Loads. *J. W. Rittenhouse*, Hi-Voltage Equipment Company

10:30 a.m. Nuclear Energy I—Grand Ballroom

Co-Chairman: *F. W. McCloska*, Sargent & Lundy

Nuclear Fuel Cycle. *F. L. Maley, D. A. Campbell*, Westinghouse

Problems of Reactor Containment. *F. B. Porzell*, ARF

10:30 a.m. Electrical Industrial Session—Assembly Room. Sponsored by Industrial Group, Chicago Section AIEE

Chairman: *R. H. Hartson*, chairman, Industrial Group, Chicago Section AIEE

Co-Chairman: *M. P. Cornelius*, International Harvester Company

Automation and Programming Control for Industrial Processes. *W. R. Harris*, Westinghouse

Effect of Voltage Transients on Industrial Control and Utilization Equipment. *G. W. Walsh*, GE.

10:30 a.m. Power Transmission and Production—Louis XVI Room. Sponsored by Power Group, Chicago Section AIEE

Chairman: *E. I. Pollard*, chairman, Power Division AIEE

Co-Chairman: *L. E. Randall*, chairman, Power Group, Chicago Section AIEE

CP58-495 Reducing Transmission System Costs and Losses. *Merrill DeMerit, K. E. Hapgood*, Tennessee Valley Authority

CP58-493 Electric Power Production and Marketing Activities of the Department of the Interior. *K. J. Plucknett*, Office of Assistant Secretary for Water and Power Development, U. S. Department of the Interior

12:15 p.m. Joint APC-WSE Luncheon—Bernard Shaw Room

Chairman: *A. G. Smith*, president, Western Society of Engineers (WSE)

Speaker: *H. A. Leedy, director*, ARF

2:00 p.m. Nuclear Energy II—Grand Ballroom

Chairman: *R. D. Maxson*, Commonwealth Edison Company

Co-Chairman: *Darwin Krucoff*, ARF

Present Status of the Sodium Graphite and Organic Moderated Reactor Concepts for Power Generation. *Sidney Siegel*, Atomics International Division, North American Aviation, Inc.

A Comparison of Three Nuclear Power Plant Concepts for Power Generation in the United States. *K. P. Cohen, E. L. Zabroski*, GE.

Nuclear Power—Where Are We Headed in Costs? *L. F. C. Reichle*, Ebasco Services Inc.

2:00 p.m. Industrial Plants—Louis XVI Room

Chairman: *M. B. Golber*, Armour & Company

Design of Small Industrial Power Plants to Secure Maximum Net Earnings. *A. A. Cummins*, Cummins & Barnard, Inc., Engineers

New Ideas for Industrial Boiler Plant Coal Handling. *A. J. Stock*, Stock Equipment Company

Short-Cut Methods of Quickly Evaluating Alternate Steam and Power Supplies for Industrial Plants. *W. B. Wilson, D. L. E. Jacobs*, GE.

2:00 p.m. Water Technology IV, Analytical and Control—Assembly Room

2:00 p.m. Symposium on Computers and Network Analyzers—Crystal Room. Sponsored by AIEE System Engineering Committee

Chairman: *L. B. LeVesconte*, Sargent & Lundy

Co-Chairman: *J. E. Van Ness*, Northwestern University

Engineering Computations for Bonneville Power Administration. *J. R. Curtin*, Bonneville Power Administration

Purchase, Annual Lease, or Hourly Rental of Digital Computers. *E. E. George*, Ebasco Services, Inc.

Digital Computer Solution of Power System Problems. *H. P. St. Clair, G. W. Stagg*, AGE Service Corporation

Electric Utility Problems Programmed for Digital Computers. *F. J. Maginnis*, GE., chairman, Applications Subcommittee, AIEE Computing Devices Committee

District No. 2 Meeting Will Cover "Engineering in the Nation's Capital"

"ENGINEERING in the Nation's Capital" has been selected as the theme for the AIEE Middle Eastern District Meeting to be held in Washington, D. C., April 28-30, 1958. Headquarters for the meeting will be the Sheraton Park Hotel.

Technical Sessions

Some 27 technical sessions and approximately 100 papers covering subjects of interest to everyone are being planned. Two joint sessions with the Institute of Radio Engineers (IRE) covering electronics have been scheduled.

Inspection Trips

Plans have been made for inspection of the Army Package Power Reactor at Fort Belvoir, Va; the National Bureau of Standards, the Naval Ordnance Laboratory, the David Taylor Model Basin, and the new WRC-TV and Radio Station.

General Session

The committee has been extremely fortunate in obtaining a speaker of national prominence for the general session on Monday morning April 28. Dr. L. V. Berkner, president of Associated Universities, Inc., in New York, N. Y., will have as his subject, "The International Geophysical Year and the Instrumented Earth Satellite."

Entertainment

The Entertainment Committee has made plans for two full evenings of pleasure. There will be a smoker on Monday night with refreshments and entertainment. Tuesday night has been designated as "Ladies Night" for the Washington Section. A social hour, dinner, and dancing should provide an interesting evening for everyone who attends the AIEE District meeting.

Ladies Events

Many interesting events and tours have been worked out to keep the ladies busy. These include the White House, one or two of the Embassies, as well as two interesting evening events.

Hotel Reservations

As April is Cherry Blossom Time in Washington and the tourist season will be well under way, it is suggested that room reservations at the Sheraton Park Hotel be made as promptly as possible. Rates are as follows:

Single with bath	$ 8.	$ 9.	$10.	$11.	$12
Twin with bath	11.	12.	13.	14.	16
Suites: 2 rooms	20.	22.	25.	30	
Suites: 3 rooms	40.	45.	50.	60	

No room charge for children under 14 years, occupying room with their parents.

Contact Reservations Manager, Sheraton Park Hotel, Washington 8, D. C., giving room choice, time of arrival, and time of departure. Be sure to mention AIEE.

Committee

Members of the Middle Eastern District Meeting Committee are: C. H. Giroux, general chairman; F. W. Willcutt, vice-chairman: J. E. O'Brien, secretary; D. E. Bender, treasurer; T. A. O'Halloran, arrangements; G. C. McCabe, finances; W. J. Ellenberger, registration; S. E. Jarosh, technical program; Gravatt and Coleman, inspection trips and transportation; Ralph Siegel, entertainment; Mrs. N. B. Ames, ladies; Dr. N. B. Ames, general session; I. F. Conrad, publicity.

Michigan State U. Campus Site of Great Lakes Meeting

The beautiful Michigan State University campus at East Lansing, Mich., will be the background for the AIEE Great Lakes District Meeting to be held May 5-7, 1958.

There will be sessions on industry, communications, education, computers, electronics, basic sciences, and all of the phases of power, including transmission, distribution, utilization, and developments in the nuclear field. One of the features in the industrial field will be a session on the electrochemical industry.

Most of the papers to be presented will be by members within the District. Many of them, which are by authors who have not written papers before, should offer some new and interesting ideas and information.

Inspection trips have been arranged to new television station WJIM-TV and the Oldsmobile plant in Lansing.

The Ladies' Activities Committee, under the chairmanship of J. D. Ryder, has announced a busy, well-planned program for the ladies. There will be campus tours including a visit to ultramodern dormitory kitchens for feeding 3,000 students, and lunch and bridge at nearby Walnut Hills Country Club.

Advance information on hotel reservation may be obtained from W. C. Peterson, Department of Electrical Engineering, Michigan State University, East Lansing, Mich. General Chairman of the meeting is Prof. J. A. Strelzoff of Michigan State University.

Official Photograph U. S. Navy

AN INSPECTION TRIP to the David Taylor Model Basin will be held during the 1958 AIEE Middle Eastern District Meeting, April 28-30, Washington, D.C.

AIEE–ASME Sponsor Management Conference

A first-hand demonstration of "Management in Action" will be offered to participants in the 6th Annual Management Conference in Boston, Mass., March 19-20, according to conference Chairman J. D. Bird. The meeting, jointly sponsored by AIEE and The American Society of Mechanical Engineers (ASME), will integrate lectures and field trips in order that attendees may hear of the latest management techniques and see them in action, said Mr. Bird.

Three organizations are participating in the "Management in Action" plan, Mr. Bird said. They are: Arthur D. Little Company, the Stone and Webster Engineering Corporation, and the Massachusetts Institute of Technology (MIT).

On the morning of March 20, Dr. L. W. Bass, vice-president of Arthur D. Little Company, will speak on the "Evaluation of Research Projects"; Howard Johnson of MIT will talk about "The Development of Engineering Personnel for Management Responsibility"; and J. J. Niland of the engineering management staff of Stone and Webster will discuss "Planning and Control of Integrated Design and Construction Projects."

In the afternoon, there will be trips to the Little Company to explore the management of a research project, to Stone and Webster to observe the construction of the third unit of the Salem Harbor power station, and to MIT to see the training of Sloan Fellows and review the management of human resources. Mr. Bird indicated that all who participate in the tours will have opportunities to speak with organization personnel.

The integrated lecture tours will follow a day of speeches on long-range planning, finance, technical effort in long- and short-term programs, and planning in the face of rapid obsolescence, said Mr. Bird.

The tentative program (headquarters for which will be in the Hotel Somerset) follows:

Wednesday, March 19

Session I

Welcome: *G. R. Northrup*, Philco Corporation

Keynote Speaker: *R. F. Dauer*, plant manager, home heating and cooling department, General Electric Company, Trenton, N. J.

Chairman: *George Muschamp*, Brown Instrument Division, Minneapolis Honeywell Regulator Company

Vice-Chairman: *J. T. Blake*, Simplex Wire & Cable Company

Company-Wide Aspects of Long-Range Planning. *H. B. Maynard*, H. B. Maynard and Company, Inc.

Competitive Position as a Yardstick of Engineering Progress. *O. E. Rodgers*, Utica-Bend Corporation

12:15 p.m. Luncheon

Presiding: *W. T. Alexander*, Northeastern University

Speaker: *L. E. Newman*, president, A. L. Smith Iron Works, Chelsea, Mass., "Some Philosophies of Management"

2:15 p.m. Session II—Developing the Theory

Chairman: *H. B. Kiputh*, Bettis Atomic Power Division, Westinghouse Electric Corporation

Vice-Chairman: *R. G. Hess*, Walworth Company

Financing for the Future. *Ralph Kelmon*, Boston Edison Company

Integrating Technical Effort in Long- and Short-Term Programs. *G. R. Northrup*, Philco Corporation

Planning Facilities in the Face of Rapid Obsolescense. *S. W. Herwald*, Westinghouse Electric Corporation

6:00 p.m. Social Hour

7:00 p.m. Banquet

Toastmaster: *C. E. Crede*, Barry Corporation

Introduction of Speaker: *E. H. Schell*, MIT

Speaker: *A. M. Lederer*, chairman of Council for International Progress in Management (U.S.A.) Inc., Morris and Van Wormer, New York, N.Y., "International Engineering Management"

Thursday, March 20

9:00 a.m. Session III—Blueprint for Action

Chairman: *G. J. Crowdes*, Simplex Wire & Cable Company

Vice-Chairman: *C. G. Parker*, New England Gas & Electric Company

Evaluation of Research Programs. *L. W. Bass*, Arthur D. Little Company

The Development of Engineering Personnel for Managerial Responsibility. *H. W. Johnson*, MIT

Planning and Control of Integrated Design and Construction Products. *J. J. Niland*, Stone & Webster Engineering Corporation

12:15 p.m. Buffet Luncheon

Orientation for "Management in Action" Visits, by *W. L. Abel*, chairman of Plant Visits Committee, United Shoe Machinery Corp

1:45 p.m. Plant Visits and Lectures

(1) Arthur D. Little, Inc.

Patent and Invention Management. Products resulting from effective patent management will be viewed (Management in Action), *A. R. Johnson*

Management in Action. History, current status, and future plans of an important research project involving two large corporations and a South American country, *B. S. Old*

New Developments in the Use of Computers in Engineering. *G. E. Kimball*

Tour of Arthur D. Little's computer facilities

(2) MIT School of Industrial Management

Objectives of the Management School. *E. P. Brooks*, dean of the School of Industrial Management

The MIT Executive Development Program. *H. W. Johnson*, associate professor of industrial management, director, Executive Development Programs

Two groups will be formed; Group 1 will observe M.A. training involving the Sloan Fellows through one-way glass windows.

Group 2 will review with D. V. Brown, Ph.D., Sloan Professor of Industrial Management, The Management of Human Resources.

Groups 1 and 2 will exchange leaders and cover the same subjects.

Assembly of whole group for coffee and discussion with members of the faculty and the Sloan Fellows.

(3) Stone & Webster Engineering Corporation

Welcoming Address: *F. W. Argue*, vice-president, member of the board of directors and engineering manager, Stone & Webster Engineering Corporation

Construction of the third unit of the Salem Harbor power station of the New England Power Co. (client of Stone & Webster) will be observed by small guided groups. This will be a semifinished project of the efforts described in the morning's talk by Mr. Niland.

AIEE Pittsfield Section

AT A RECENT SECTION MEETING, 14 members received awards for their valued contributions to the AIEE Pittsfield Section and to the Institute, including: (*left to right*) S. R. Smith, Fellow; W. J. Degnan, co-author Section first prize paper; A. Glassanos, outstanding member, Membership Committee; T. H. Brownlee, Fellow; W. A. Keen, Jr., co-author District first prize paper and Section second prize paper; G. G. Doucette, co-author Section first prize paper; D. R. Powell, co-author District first prize paper and Section second prize paper; J. L. Cantwell, Fellow; R. B. Kaufman, co-author Section third prize paper; W. A. McMorris, past Section chairman; and T. W. Liao, co-author District first prize paper. Also receiving awards but not present were: R. J. Ringles, co-author Section first prize paper; K. H. Weber, co-author Section third prize paper; and J. R. Meador, past chairman Transformers Committee.

First Joint Conference on Automatic Control Techniques

The first Joint Conference on Automatic Control Techniques, sponsored by AIEE, The American Society of Mechanical Engineers (ASME), and Institute of Radio Engineers (IRE), is scheduled to convene in Detroit, Mich., at the Hotel Statler April 14-16, 1958. Under the co-direction of G. W. Heumann, chairman, AIEE Joint Division Committee on Automation and Data Processing, and T. H. Belcher, Michigan Section AIEE, the forum will include four technical sessions, a panel discussion, and an inspection trip.

In describing the function of the conference, Mr. Heumann said the meeting will bring together, for the first time, members of the principal professional engineering societies who are making use of electrical, electronic, mechanical, hydraulic, and pneumatic media to solve automatic control and data handling problems for industrial production. While engineering considerations will dominate the technical sessions, heavy emphasis will be laid on improved performance resulting from the use of automatic control and data handling techniques, Mr. Heumann added.

The program committee is composed of W. R. Harris, AIEE, chairman; F. D. Snyder, ASME; C. A. Priest, IRE; G. W. Knapp, AIEE; and A. R. Satullo, AIEE Michigan Section. Mr. Harris reported that the papers (all of which are committed) will provide an outstanding program in terms of timeliness, diversification, and technical achievement.

Pulp and Paper Industry Subcommittee Plans Conference

Aspects of automation in the paper and pulp industry will be part of the program heard by some 200 ranking electrical engineers and their industry associates when they assemble March 27-28 at North Carolina State College, Raleigh, N. C., for the annual Conference sponsored by the AIEE Pulp and Paper Industry Subcommittee.

Technical papers scheduled to be read include "Electronic Memory Dispatching for Material Handling" and two different ones on "Static Elements for Control of Rapid Cycle Digesters."

Other papers will cover such subjects as "Systems for Precision Measurement of Machine Speed and Section Draw," "Protective Relay Co-ordination," "Evaluation of Wiring Systems," and "Factors in the Selection and Purchase of Electrical Apparatus."

This year, the Conference, which is usually held on the campus of some leading college or university, is being held through the co-operation of the department of electrical engineering and the

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until March 28. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., on or before March 28.

57-119 Cascade Potential Transformers. *G. Camilli, H. R. Lucas, L. W. Marks, C. H. Tuttle*

57-1005 A Modified Adjustable-Speed Brushless Induction Motor. *A. M. El Gammal*

57-1090 International Activities in the Temperature Classification of Electrical Insulating Materials. *L. J. Berberich, K. N. Mathes*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N. Y.

College Extension Division of North Carolina State College. The program promises a wide array of technical papers to be presented by leading electrical engineers from the mills and associated industries.

Advance copies are not available; however, a conference booklet containing all papers to be presented will be available at the time of registration.

G. I. Burner, Rust Engineering Company, Pittsburgh, Pa., is chairman of the AIEE Pulp and Paper Industry Subcommittee; C. H. Hudson, General Electric Company, Atlanta, Ga., who is serving as chairman of the Conference Arrangements Committee is vice-chairman; and E. K. Murphy, Rayonier, Inc., Jesup, Ga., is secretary.

Several inspection trips to nearby industrial sites are planned as well as an opportunity to view the newly dedicated Reuben B. Robertson Laboratory of Paper Technology on the campus.

The tentative technical program follows.

Thursday, March 27

9:00 a.m. Registration

10:30 a.m. Morning Session

Address of Welcome

Co-ordination of Protective Relays in a Paper Mill. *W. W. Pruitt,* J. E. Sirrine Company

Factors Involved in Selection and Purchase of Electrical Apparatus. *H. B. Whitworth,* The Champion Paper & Fibre Company

12.30 p.m. Luncheon

2:30 p.m. Afternoon Session

CYPAK Control of Rapid Cycle Digesters. *W. A. Roth,* Westinghouse Electric Corporation

Static Switching Control of Rapid Cycle Digesters. *G. J. Hess,* General Electric Company

Evaluation of Three Wiring Systems Applied to the Pulp and Paper Industry. *J. F. Steedley,* Bowaters Research and Development, Inc.

5:00 p.m. Adjourn for Day

6:00 p.m. Social Hour

7:00 p.m. Banquet

Friday, March 28

9:45 a.m. Morning Session

A-c Systems for Precision Measurement of Machine Speed and Section Draw. *G. M. Butler,* Curtis-Wright Corporation

D-c Systems for Precision Measurement of Machine Speed and Section Draw. *W. Mikelson,* General Electric Company

Material Handling System with Electronic Memory for Dispatching. *H. Stephenson,* Jervis B. Webb Company

12:00 Noon Luncheon

2:30 p.m. Inspection Trips

Reservations are now being accepted at the Sir Walter Hotel (400 rooms) and the Hotel Carolina (250 rooms) in Raleigh and should be made as soon as possible.

"Contrasts in Computers" Will Be Theme of Conference

The first national symposium on modern computer design methods and application techniques—at which leading authorities in the field will argue the relative merits of various systems and components—will take place in Los Angeles, Calif., May 6-8 at the Ambassador Hotel, under the chairmanship of Dr. W. H. Ware.

Highlight of the 1958 Western Joint Computer Conference—the unusual panel discussion, under the general theme of "Contrasts in Computers," will devote three full days to an exhaustive debate of six controversial subjects in the field of computer design and application.

In announcing the symposium, Montgomery Phister, Jr., technical program chairman of the Conference, stated that "Many different organizations all over the United States are designing and using computers in many different ways. Each organization has developed a specific set of methods and procedures and, although it is aware of other ways of doing things, is generally convinced its way is best. The purpose of this conference is to bring these contradictory points of view together in one place and at one time so that they can be argued and compared by experts in the field."

Among the topics scheduled for discussion are "Logical Design Methods," with Dr. Gene Amdahl as chairman, in which block diagrams and logical equations will be contrasted; "Active Elements for the Machine," with Prof. Ralph Meagher as chairman and four experts arguing the case for magnetic cores, cryotrons, transistors, and special vacuum tubes; "Logical Circuitry for Transistor Computers," with J. H. Felker as chairman in which the comparative values of resistor-transistor, direct-coupled, symmetrical and "stretch" logic will be presented; and "Solution of Ordinary Differential Equations," with Wesley Melahn as chairman, which will consider the relative advantages, in this respect, of general-purpose computers, analog computers, combination digital and analog, and digital differential analyzers. Also on the agenda will be sessions on "Command Structure" and "Very Large Files," chairmanned respectively by Dr. J. W. Carr and Dr. A. J. Perlis.

The 1958 Western Joint Computer Conference is cosponsored by the AIEE, Institute of Radio Engineers, and the Association for Computing Machinery (ACM). In addition to the panel discussions, individual papers will be presented during the course of the conference, which is scheduled for May 6-8. Also, the following day, May 9, will be given over to "Small Computers—A Report from the Manufacturers," sponsored by the Los Angeles Chapter of the ACM.

EJC President Discusses U.S. Technological Situation

"The United States is challenged now as a world power because of misdirection of its technological program, not because of the lack of present technological capability."

E. R. Needles, prominent consulting engineer, made this statement at his installation on January 10, 1958, as president of Engineers Joint Council (EJC), the unity organization of the engineering profession. When he took office at the board of directors meeting, Mr. Needles made four points, summing up the present situation as it relates to engineering and science.

"The situation in which we find ourselves," said Mr. Needles, "is not the result of technological failure. It is rather the result of mistaken decisions in program emphasis and manpower administration during the past decade. To ascribe the Russion rocket and satellite lead to weakness in American technology is misleading and erroneous. There is no evidence to indicate that the 'race' is temporarily lost for technological reasons.

"There is no question but that any one of several engineering and scientific organizations could have won the 'race' to get an earth's satellite into the air if this had been considered of prime political significance, and if this was to have been used as the basic measure of our technological excellence. We have not lost our technological leadership or engineering

productivity, but we must push everlastingly forward in our educational processes for engineers and scientists and the orderly and intelligent administration of their endeavors and services."

Supplementing these thoughts, in his second point Mr. Needles emphasized that "educational reform can have absolutely no effect on our technological performance during the crucial next three years when our technical accomplishments must be truly in keeping with our great capabilities, to restore the temporarily dimmed prestige of the United States. The first step the country must take is to provide adequate administration and direction for the technological team of scientists and engineers which exists.

"Guns or butter," continued the President of EJC, "is a cliche inconsistent with the technological capacity of this country. From the point of view of our engineering and scientific capacity, there is no reason why the United States cannot have, at one and the same time, a continuing rise in the living standard and a defense capacity of ever-increasing strength."

In his fourth point, Mr. Needles stressed the need for caution in long-range fundamental educational programs. "Educational re-emphasis," he concluded, "which can have only long-range effects should be concerned primarily with the quality of that education rather than the quantity."

To underscore the authority of his estimate of the current crisis in engineering and science, Mr. Needles pointed out that in January 1955 EJC, together with the Columbia School of Engineering, warned the nation of the new perilous position of this country in a press conference entitled "The Cold War for Engineering Manpower" in which, for the first time, the United States lag in manpower and misuse of its technological team was made clear to the American public.

"The role of Engineers Joint Council, the organization through which the engineering profession can make itself heard," concluded Mr. Needles, "is more vital than ever. And in this instance it is saying most emphatically that the technical force of the United States is capable of meeting any challenge to world supremacy, providing it is given the responsibility and administration it needs."

EJC is a federation of 17 major national and regional engineering societies representing more than 250,000 of the nation's engineers.

Conference on Automatic Optimization, April 2-4, 1958

Four technical sessions and a panel discussion will provide the technical part of the Conference on Automatic Optimization sponsored by the Instruments and Regulators Division of The American Society of Mechanical Engineers (ASME) with participation by AIEE, Institute of Radio Engineers, Instrument Society of America, and American Institute of Chemical Engineers, scheduled for April 2-4, 1958, at the University of Delaware.

Plant visits and social activities also have been arranged by the local program committee. Conference registrants may choose from the following plant visits during the afternoon of April 2: Tidewater Oil's new Delaware City refinery (features the latest in refinery instrumentation); Electromechanical department, Mechanical Development Laboratory, E. I. du Pont de Nemours & Co. (Inc.) (develops automatically controlled mechanical processes); Chrysler–Plymouth assembly plant; Delaware Power and Light Generating Station.

The tentative technical program for the Conference follows:

Wednesday, April 2

Morning Session I

Optima—What They Are and How To Find Them. *G. E. P. Box*, Princeton University

Principles of Designing an Optimizing System when Equations Are Not Available. *W. F. Galey*, Pittsburgh Plate Glass

Evaluation of Strategies for Automatic Experimentation. *R. I. Van Nice, A. F. Kaupe, Jr.*, Westinghouse Electric Corporation

Afternoon Session II

An Adaptive Humidity Control System. *G. K. Tucker*, Brown Instruments Division, Minneapolis-Honeywell Regulator Company

A Technique for Optimizing Process Conditions. *A. L. Hoerl*, E. I. du Pont de Nemours & Co. (Inc.)

Optimizing Transient Stability in Batch Processing. *D. P. Eckman, I. Lefkowitz*, Case Institute of Technology

Evening Session III

Panel discussion of problems, challenges, and opportunities in automatic optimization. Chairman W. E. Vannah is inviting five panelists from the aircraft, chemical processing, electrical utility, steel manufacturing, and control manufacturing industries.

Thursday, April 3

Morning Session IV (General)

Application of Hydraulic Control to Reagent Flow Regulation. *H. Markarian, J. B. Reynolds, Jr.*, E. I. du Pont de Nemours & Co. (Inc.)

Sheet-Length Gage for Ferrostan Line. *J. A. Milnes*, U. S. Steel Corporation

Analysis and Design of Boiler for Optimum Performance. *E. I. Ergin*, Beckman Systems Division

Morning Session V

Continuous Measurement of System Characteristics: A Step Toward Self-Optimizing Control. *T. P. Goodman, R. H. Hillsley*, Massachusetts Institute of Technology

Servo with Automatic Gain Control. *E. R. Walters*, Bendix Radio

Adaptive Filters for Random Inputs. *C. W. Steeg, Jr.*, RCA Airborne Systems Laboratory

People planning to attend should request registration blanks from L. Bertrand, Instrument Department, Engineering Service Division, Louviers Building, E. I. du Pont de Nemours & Co. (Inc.), Newark, Del.

Machine Tool Conference

SHOWN at the 9th Annual Machine Tool Conference are (*seated, left to right*) William Ryan, president, The American Society of Mechanical Engineers; H. E. Ankeney, past chairman, Machine Tool Subcommittee; E. F. Mekelburg, publicity chairman for the 9th Annual Machine Tool Conference; W. J. Barrett, AIEE president; and (*standing*) R. J. Ungrodt, chairman, Milwaukee Section of AIEE.

COMMITTEE ACTIVITIES

EDITOR'S NOTE: *This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.*

General Applications Division

Land Transportation Committee (E. A. Foster, *Chairman;* P. G. Lessman, *Vice-Chairman;* J. C. Price, *Secretary*). Early in 1957, the chief American delegate to the International Electrotechnical Commission (IEC) Committee No. 22 on Power Converting Equipment invited the Land Transportation Committee to act as technical adviser to the IEC U. S. National Committee in appraisal of a document: "Rules for Sub-Station Equipment and Apparatus for Feeding Traction Networks." An advisory group was formed under the sponsorship of this Committee and several members submitted reports concerning traction load conditions on properties with which they are familiar. These reports were forwarded to the chief American delegate for use at the IEC Meeting in Moscow, USSR, in July 1957.

Instrumentation Division

Electronic and High Frequency Instruments Committee (Ferdinand Hamburger, Jr., *Chairman;* J. W. Kearney, *Vice-Chairman;* W. C. Gore, *Secretary*). The Electronic Instruments Subcommittee will publish shortly several specification guides for electronic instruments and is making progress on completing one for regulated d-c power supplies.

Power Division

Transmission and Distribution Committee (I. B. Johnson, *Chairman;* H. L. Davis, Jr., *Vice-Chairman;* J. T. Lusignan, Jr., *Secretary*). Activities of the Committee and its Subcommittees and Working Groups include the following.

1. *Distribution Subcommittee.* There is considerable public pressure to improve the appearance of aerial distribution circuits and consideration is being given to increased use of aerial cable and to reduction of the number of circuits on a pole. Studies also are in progress to make underground construction more economically attractive.

The use of plastic pipe for domestic water systems appears to be creating problems in connection with distribution circuit grounding. Data on this problem is being assembled.

2. *General Systems Subcommittee.* The Working Group on Switching Surges has decided that sufficient new information is available to revise the 1948 report on transient overvoltages. This interim measure is desirable because the present program may take several years to complete.

The Working Group on System Stability is engaged in studies to revise the 1937 report on system stability as soon as possible.

3. *Lightning and Insulator Subcommittee.* A review of current data is being made to determine the advisability of revising the AIEE method of calculating frequency of flashover of high voltage lines. Also under study are the following topics: the number of insulators required to meet certain conditions relative to the wet flashover of the insulators; the use of silicone or other oils or waxes on insulator surfaces for operation in contaminated areas; and the effectiveness of Cougnard deionisers.

4. *Towers, Poles, and Conductors Subcommittee.* The more effective application of aluminum, high strength steel, and wood poles in the construction of transmission structures is the topic of considerable study and discussion.

Corrosion of the steel core of ACSR conductors is a problem that faces some utilities. Aluminized strands have shown promise of being better than zinc galvanized in ability to resist this corrosion.

5. *"What's New in T&D."* Martin Lantz described the use of the IBM Digital Computer *650* on the Bonneville Power Administration system. He indicated its marked superiority over network analyzers for solving his transmission line problems.

N. C. Spencer described problems that Gulf States Utilities had encountered in stringing all-aluminum conductor. Determination of proper pre-stretching tensions eliminated undesirable sag changes.

AIEE PERSONALITIES

Reinhold Rüdenberg (F '50), Gordon McKay Professor of Electrical Engineering, Emeritus, at Harvard University, was recently awarded the Commander's Cross of the Order of Merit of the Federal Republic of Germany by His Excellency Dr. Theodor Heuss, president of the Federal Republic of Germany (West Germany). Presentation of the insignia of the Order and the certificate of award was made by Dr. W. L. von Holleben, German consul in Boston, Mass., at a private ceremony. Prof. Rüdenberg previously has been honored by the Berlin University of Technology and the Karlsruhe Institute of Technology in Germany; the Universities of Technology in Sweden; Liege University, Belgium; and Stevens Institute of Technology in the United States. He has lectured at many universities in Germany, and at the Universities of Rio de Janeiro and Sao Paulo, Brazil; the University of Montevideo, Uruguay; and the Massachusetts Institute of Technology. Prof. Rüdenberg served on the AIEE Standards Committee (1939-50), and was liaison representative on the Standards Committee (1951-55).

J. D. Ryder (AM '40, F '51), dean of engineering, Michigan State University, East Lansing, Mich., has been appointed editor of the Institute of Radio Engineers to succeed **D. G. Fink** (M '45, F '51), director of research of the Philco Corporation. Mr. Ryder has served on the following AIEE Committees: Electronics (1946-57); Education (1949-57, chairman 1952-54); Computing Devices (1951-56); Fortescue Fellowship (1951-54); Student Branches (1951-52, 1953-55); Technical Operations (1952-54); Research (1955-57); and Edison Medal (1955-60).

H. C. Martin (AM '43, M '45), vice-president of the Ambos-Jones Company, has become president of Martin-Rettger, Inc. After graduating from Rensselaer Polytechnic Institute as an electrical engineer, Mr. Martin joined the engineering department of Ward Leonard Electric Company. For the past 22 years, he has been associated with the Ambos-Jones Company, a portion of whose activities will be continued by Martin-Rettger, Inc. Mr. Martin is currently vice-chairman of the AIEE Cleveland Section and chairman of the Section Meetings and Papers Committee. **W. V. Rettger** (AM '46), is vice-president of Martin-Rettger, Inc. Mr. Rettger, who graduated from Cornell University, also was employed with Ward Leonard Electric Company. He was associated with the Ambos-Jones Company for 19 years excluding two periods in the U. S. Air Force from which he resigned as a Lt. Colonel. Mr. Rettger has been active on many AIEE Cleveland Section Committees.

H. L. Hoeppner (AM '18, F '43, Member for Life), chief electrical engineer, Pioneer Service & Engineering Co., Chicago, Ill., has been appointed consulting electrical engineer. **W. F. Bergmann** (AM '36, M '46), senior electrical engineer, has assumed Mr. Hoeppner's duties. Mr. Bergmann served on the AIEE Transformers Committee (1955-57).

A. N. Horne (M '54), vice-president and general manager of the Texaco–Cities Service Pipe Line Company, and **G. R. Milne** (AM '21, F '49, Member for Life), chief mechanical engineer for the Consolidated Edison Company of New York, have been transferred to the rank of Fellow of The American Society of Mechanical Engineers. Mr. Horne has served on the AIEE Petroleum Industry Committee (1955-57). Mr. Milne has been a member of the AIEE Power Transmission and Distribution Committee (1937-42) and Electrical Machinery Committee (1942-43).

W. E. Chope (AM '50), president, Industrial Nucleonics Corporation, Columbus, Ohio, has been chosen as one of America's 10 Outstanding Young Men of 1957 by the U.S. Junior Chamber of Commerce.

G. B. Tebo (AM '36, M '44), director of employee relations and director of the Organization Services Division, Hydro-Electric Power Commission of Ontario, Toronto, Ont., Canada, has been appointed manager of the CSA (Canadian

Standards Association) Testing Laboratories. Mr. Tebo served on the AIEE Research Committee (1954-57) and Standards Committee (1956-57).

J. V. McGuire (AM '47), manager of the switchgear department, Allis-Chalmers Manufacturing Company, has been appointed assistant general manager of the Allis-Chalmers Pittsburgh (Pa.) Works. **D. W. Webb** (AM '48), manager of sales, switchgear assemblies and unit substations, succeeds Mr. McGuire. Mr. McGuire was a member of the AIEE Industrial Power Systems Committee (1952-56) and Substations Committee (1952-53). Mr. Webb served on the AIEE Substations Committee (1954-57).

J. W. McNair (AM '25), assistant technical director, American Standards Association (ASA), New York, N. Y., has been appointed technical director. He also was made assistant secretary of the ASA.

E. C. Chamberlin (M '49), assistant vice-president, planning, The Western Union Telegraph Company, New York, N. Y., has been appointed general manager of the 12-state Eastern Division of Western Union. Mr. Chamberlin has served on the following AIEE Committees: Telegraph Systems (1949-55, chairman 1951-53); Communication Division (1951-56); and Special Communication Applications (chairman 1953-56).

R. E. Kirby (AM '53), manager of the ordnance department, Westinghouse Electric Corporation, has been appointed manager of the Westinghouse electronics operation in Baltimore, Md. Mr. Kirby served on the AIEE Electric Heating Committee (1954-55).

F. L. Miller (AM '40, M '45), manager—product planning, specialty control department, General Electric Company (GE), Waynesboro, Va., has been appointed manager—marketing for the GE power tube department, Schenectady, N. Y.

OBITUARIES

Willis Rodney Whitney (AM '01, Member for Life), dean of industrial research in America, died recently in Schenectady, N.Y. He was 89 years old. In 1900, Dr. Whitney founded the General Electric (GE) Research Laboratory. He served as its director for 32 years, a period during which scientists under his leadership made many of the major discoveries that helped bring electricity into homes and factories throughout the world. He was an honorary vice-president of GE. Dr. Whitney was born at Jamestown, N.Y., on August 22, 1868. He was graduated from Massachusetts Institute of Technology (MIT) with the degree of B.S. in 1890 and received his Ph.D. in chemistry from the University of Leipzig, Germany, in 1896. Following his graduation, Dr. Whitney held several positions at MIT, including assistant professor of theoretical chemistry, nonresident associate professor of theoretical chemistry, and, after 1908, nonresident professor of chemical research, a title which he still held at the time of his death. In 1900, although he had stated that he would rather teach than be president, he went to GE with the prospect of working with the great Dr. Charles Steinmetz and a promise that he would be given full freedom to continue his work in any field he wished. From 1900 to 1932, Dr. Whitney was active director of the Research Laboratory. During the last four years of this period he also served as vice-president in charge of research for the company. In 1932, he retired from directorship of the laboratory and, in 1941, from the vice-presidency. Since that time, he had continued research in the capacity of honorary vice-president and consultant to the laboratory. His establishment and development of the GE Research Laboratory was perhaps his best-known achievement. This laboratory, the first industrial research laboratory in the country devoted to basic research, set the pattern for fundamental scientific research in industry. The Research Laboratory now has a staff of 13,000, including 400 scientists. Dr. Whitney was a life member of the Corporation of MIT, and he was also on the U.S. Naval Consulting Board established during World War I. He was a member of the National Academy of Sciences; National Research Council; American Chemical Society (he once served as president of that body); the American Electrochemical Society (its president in 1912); American Institute of Mining, Metallurgical, and Petroleum Engineers; American Society for the Advancement of Science; American Academy of Arts and Sciences; American Physical Society; The Franklin Institute; American Philosophical Society; British Institute of Metals; and the French Legion of Honor. Many colleges and universities awarded honorary degrees to Dr. Whitney, including the University of Pittsburgh, Union College, Syracuse University, University of Michigan, University of Rochester, and Lehigh University. Other honors bestowed on Dr. Whitney both here and abroad include: AIEE Edison Medal, Willard Gibbs Medal, Chandler Medal, Perkin Medal, Franklin Medal, Edison Medal, decoration of Chevalier of the Legion of Honor (France), gold medal of the National Institute of Social Sciences, 1943 John Fritz Medal, distinguished service gold key of the American Congress of Physical Therapy, the Marcellus Hartley Gold Medal, and the medal of the Industrial Research Institute. He was the author of many scientific publications in such fields as the iron corrosion, solubility determinations, colloids, alloys, chemistry of light, carbon brushes, catalysis phenomena, vacuums, and electrochemistry. Dr. Whitney had served on several AIEE Committees.

Dr. W. R. Whitney

William Smart Bishop (AM '06, Member for Life), retired electrical engineer, died recently. Mr. Bishop was born October 17, 1879, in Lyons, N.Y. He graduated from Cornell University in 1906 with the degree of M.E. (electrical engineering option). Upon the completion of the Students Training Course of Allis-Chalmers Manufacturing Company, he was assigned to their Boston, Mass., office. He soon transferred to the Massachusetts Lighting Companies. Mr. Bishop became electrical engineer of the Massachusetts Lighting Companies and was a director of some of the companies for its successor, the New England Power Company. He was the rate research engineer at the time of his retirement in 1951.

John Lewis Jones (AM '21, M '39, Member for Life), toll plant manager, Southwestern Bell Telephone Company, Oklahoma City, Okla., died recently. He was 60 years old. Mr. Jones was born in St. Louis, Mo., where he first joined Southwestern Bell Telephone Company. In 1937, he transferred to Oklahoma City where he became toll plant manager. Mr. Jones was an employee of the company for 44 years. During World War I, he had served with the U. S. Army. Mr. Jones was an active member of the Oklahoma Section of the AIEE and at one time was Section chairman.

Winfred Henry Stueve (M '43, F '54), consulting engineer, Oklahoma City, Okla., died recently at the age of 72. Mr. Stueve was born August 5, 1885, in Wapakoneta, Ohio. After graduating from Ohio State University in 1908, he became a consulting engineer for municipal power plants and distribution systems in Tulsa and Muskogee, Okla. During World War I, he served in the U. S. Navy after which he returned to Muskogee as consulting electrical engineer. He joined the Oklahoma Gas and Electric Company (OG&E) in 1925, transferring to Oklahoma City in 1929. Mr. Stueve was one of the pioneers in the use of electric power in oil field pumping. After 25 years with OG&E, he retired in 1950 as an executive assistant; however, he continued to be active as a consulting engineer. Mr. Stueve was a fellow of The American Society of Mechanical Engineers; a past president of the Petroleum Electric Power Association; chairman of the Missouri Valley Electric Association; and a member of the Edison Electric Institute, American Institute of Mining, Metallurgical, and Petroleum Engineers, Eta Kappa Nu, and the Oklahoma City Chamber of Commerce. Mr. Stueve served on the AIEE Special Committee on Registration of Engineers (1943-46) and the Petroleum Industry Committee (1954-57).

Wilbur L. Webb (AM '49, M '52), general manager of the Missile Section of Bendix

Aviation Corporation, died recently. Mr. Webb attended the State College of Washington, where he received his B.S. degree in E.E. in 1929, and was elected to Tau Beta Pi and Sigma Tau. He was a radio engineer with the Bell Telephone Laboratories in New York, N. Y., from 1930 to 1935, and chief engineer of Lear Developments, Inc., from 1935 to 1936. He joined the Radio Division of Bendix in Baltimore, Md., in 1936, advancing to the post of director of engineering and research and, in 1952, was named general manager of the new operation established by Bendix in Mishawaka, Ind., to build the Talos missile for the U.S. Navy. A pioneer in the field of electronic development, Mr. Webb designed the automatic radio direction finder that has since become a standard aircraft navigational aid and was honored by the Navy for his participation during World War II in the design of ground-controlled-approach radar (GCA). Mr. Webb was a fellow of the Institute of Radio Engineers, and a member of the guided missiles committee of the Aircraft Industries Association, the Institute of Navigation, Society of Automotive Engineers, Army Ordnance Association, American Rocket Society, and the Radio Technical Committee for Aeronautics.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of January 16, 1958, recommended the following applications for transfer. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Andrews, D. L., distribution studies engineer, engineering dept., Idaho Power Co., Boise, Idaho

Beck, H. A., electrical engineer, Electrical Branch, U. S. Bureau of Reclamation, Denver Federal Center, Denver, Colo.

Beville, J. W., Jr., assistant system engineer, Florida Power and Light Co., Miami, Fla.

Birx, D. L., senior research engineer, The Franklin Institute, Philadelphia, Pa.

Bleikamp, R. P., industry engineer, industry engineering dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

Brain, J. W., partner, Lutz & May Co., Kansas City, Mo.

Brockert, P. E., project engineer, aeroproducts (Allison Div. GMC), Municipal Airport, Dayton, Ohio

Bryant, C. A., electrical engineer, GS-12, U. S. Navy, District Public Works Office, Design Div., Pearl Harbor, Hawaii

Buffo, M. A., electrical engineer, Transmission Plant Design Section, Bureau of Reclamation, Denver Federal Center, Denver, Colo.

Clark, A. D., assistant chief, Ground Electrical Power Branch, Aeronautical Accessories Lab., USAF (WADC), Wright-Patterson AFB, Dayton, Ohio

Clark, R. F., special studies engineer, engineering dept., Southern Bell Tel. & Tel. Co., Atlanta, Ga.

Cook, L. H., superintendent, transmission design, Transmission Section, British Columbia Engineering Co., Vancouver, B. C., Canada

Cramer, T. A., manager-carrier current, engineering, communication products dept., General Electric Co., Syracuse, N. Y.

Davenport, T. H., junior engineer, engineering dept., New England Power Service Co., Milford, Mass.

Dean, F. P., line engineer, industry control dept., General Electric Co., Roanoke, Va.

Debaste, E., electrical designer, Pulp & Paper Div., Chas. T. Main, Inc., Boston, Mass.

Donovan, R. E., electrical engineer, electrical distribution dept., Public Service Co. of Colorado, Denver, Colo.

Drane, G. M., partner, Consulting Engineers of Hawaii, Honolulu, Hawaii

duBreuil, F. L., development engineer, The Jeffrey Mfg. Co., mining research & development dept., Columbus, Ohio

Eyman, D. R., southeast division engineer, engineering dept., Florida Power & Light Co., Fort Lauderdale, Fla.

Fiedler, H. J., application engineer, user industries sales dept., General Electric Co., Schenectady 5, N. Y.

Fleming, P. J., engineer, The Hartford Electric Light Co., Hartford, Conn.

Goldberg, M. Om., transmission & protection engineer, engineering dept., Mountain States Tel. & Tel. Co., Helena, Mont.

Goodkin, S. S., supervisor electronic maintenance, Sylvania Electric Products, Inc., Ottawa, Ohio

Grant, L. A., president, High Voltage Systems, Inc., Toledo, Ohio

Groce, J. C., senior project engineer, ECM Laboratory, Federal Telecommunication Labs., Nutley, N. J.

Hayley, A. L., Jr., electrical engineer, electric production dept., Louisville Gas & Electric, Louisville, Ky.

Helmick, C. G., Jr., senior engineer, industry engineering dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

Hugo, R. V., engineer, electric system planning dept., Public Service Co. of Colorado, Denver, Colo.

Kelly, W. L., application engineer, user industries sales dept., General Electric Co., Denver, Colo.

Landoll, L. E., engineer, Ohio Edison Co., Akron, Ohio

Leitch, D., Jr., engineer-in-charge, Station Equipment Section, Philadelphia Electric Co., Philadelphia, Pa.

Levy, F. E., assistant engineer of construction, Dept. of Water & Power, City of Los Angeles, Calif.

Linsley, F. H., transmission & distribution engineer, engineering dept., The Hartford Electric Light Co., Hartford, Conn.

Mahon, E. G., design engineer, electrical dept., Shawinigan Engineering Co., Montreal, Que., Canada

Maler, G. J., assistant professor, electrical engineering dept., University of Colorado, Boulder, Colo.

Miller, D. W., plant extension engineer, The Pacific Tel. & Tel. Co., Seattle, Wash.

Moore, G., manager, graduate student training dept., Westinghouse Educational Center, Pittsburgh, Pa.

Nash, W. H., development engineer, engineering dept., Line Material Industries, South Milwaukee, Wis.

Osborne, E. F., senior engineer, Air Arm Div., Westinghouse Electric Corp., Baltimore, Md.

Parkinson, L. J., unit manager, industry control dept., General Electric Co., Roanoke, Va.

Redmon, J. K., sales engineer, industrial dept., Westinghouse Electric Corp., Newark, N. J.

Schaller, R. E., supervising engineer, state area engineering dept., Illinois Bell Telephone Co., Chicago, Ill.

Shadeed, E. N., electrical engineer, Electrical Div., Shawinigan Engineering Co. Ltd., Montreal, Que., Canada

Shedd, R. D., line engineer, industry control dept., General Electric Co., Roanoke, Va.

Shell, C. B., superintendent-electric construction, Ohio Edison Co., Akron, Ohio

Shepherd, R. L., assistant engineer, electric distribution dept., Public Service Electric & Gas Co., Camden, N. J.

Stevens, R. H., engineer, Miami Area engineering dept., Florida Power & Light Co., Miami, Fla.

Sturdivant, M.S., superintendent, Brazos Electric Power Co-operative Inc., Waco, Texas

Sturton, A.B., protection design engineer, Engineering Div., The Shawinigan Water & Power Co., Montreal, Que., Canada

Thain, W. N., supervisor, Branch of System Operations, Southwestern Power Administration, Tulsa, Okla.

VanAllen, H. M., toll plant manager, Toll Plant Div., British Columbia Telephone Co., Vancouver, B. C., Canada

Watson, J. E., director of power utilization, Tennessee Valley Authority, Chattanooga, Tenn.

Watts, J. H., Jr., Corpus Christi manager, Westinghouse Electric Corp., Corpus Christi, Texas

Weiss, N. S., associate engineer, electrical dept., Whitman, Requardt & Associates, Baltimore, Md.

Williams, A. F., Jr., senior electrical engineer, engineering dept., Transcontinental Gas Pipe Line Corp., Houston, Texas

Willis, R. E., district transformer specialist, user sales dept., General Electric Co., Denver, Colo.

Wilson, I. L., underground engineer, distribution engineering dept., Oklahoma Gas & Electric Co., Oklahoma City, Okla.

Wilt, H. J., engineer, industry control dept., General Electric Co., Roanoke, Va.

59 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member have been received from the following candidates, and any member objecting to election should so notify the Secretary before March 25, 1958, or May 25, 1958, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Alhashmi, H. A., lecturer, Aligarh University, Aligarh, India

Barnitz, R. W., chief electrical engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

Bateman, R., acting chief engineer, Page Communications Engineers, Washington, D.C.

Blomquist, S. A., partner, Blomquist & Brown, Salt Lake City, Utah

Confeld, J. D., section head, Systems Planning, Stromberg-Carlson Co., Rochester, N.Y.

Dasher B. J., director, School of Engineering, Georgia Institute of Technology, Atlanta, Ga.

Davis, D. D., development engineer, General Electric Co., Pittsfield, Mass.

Geiger, E. S., superintendent of operations, Tampa Electric Co., Tampa, Fla.

Gerard, H. V. P., head of researches, Ste. Geoffroy Delore, Clichy, Seine, France

Goodwin, E. F., engineer, Southern Bell Tel. & Tel. Co., Atlanta, Ga.

Hansen, R. E., manager-standard mobile design engineering, communication products dept., General Electric Co., Syracuse, N.Y.

Higgins, D. N., Jr., chief power engineer, Brown & Root, Inc., Houston, Texas

Howell, A. S., principal engineer, Stromberg Carlson Co., Rochester, N.Y.

Ivanson, J. E., design & construction job engineer, Ebasco Service, New York, N.Y.

Kittle, G. B., electrical engineer, David W. Murray Co., Cleveland, Ohio

Levi, E., senior research fellow, Microwave Research Inst., Brooklyn, N.Y.

Mathews, J. B., extensions engineer, Southern Bell Tel. & Tel. Co., Atlanta, Ga.

McAllister, J. C., supervisor, instrumentation development, McDonnell Aircraft Corp., St. Louis, Mo.

Mercier, F. E., engineer, Commonwealth Edison Co., Chicago, Ill.

Mitchell, J. R., general engineering personnel supervisor, Pacific Tel. & Tel. Co., Seattle, Wash.

Nilsson, V. N., superintendent, underground dept., Ohio Edison Co., Youngstown, Ohio

Norviel, H. D., research associate, ordnance research laboratory, Pennsylvania State University, University Park, Pa.

O'Rouark, T., consulting electrical engineer, 329 Yates Bldg., Boise, Idaho

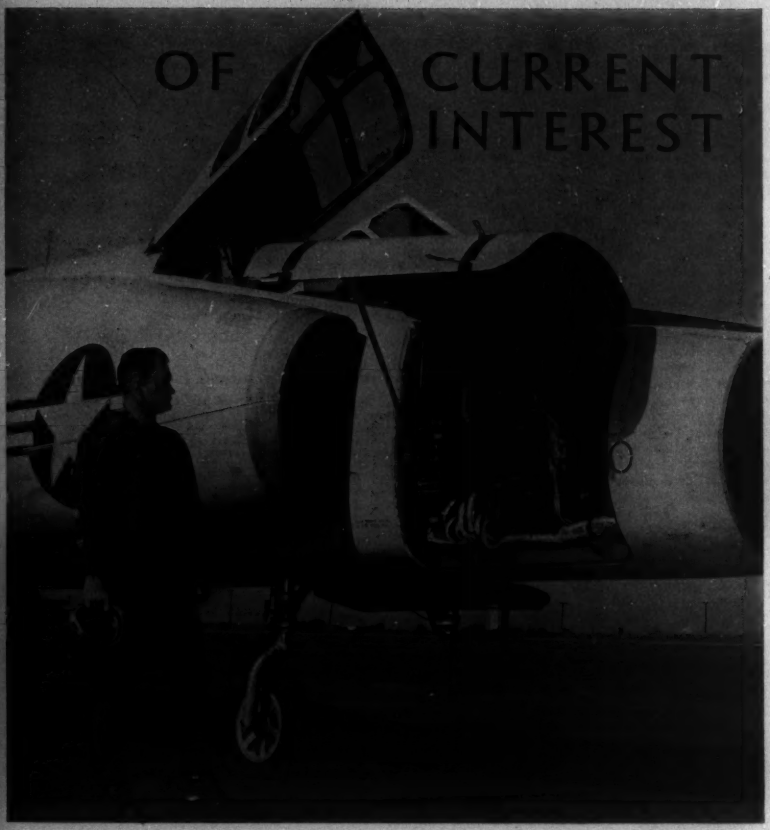
Perkins, E. H., design engineer, General Electric Co., Ft. Wayne, Ind.

Pinkney, R. W., consulting engineer (partner), Pinkney and Hine, Minneapolis, Minn.

Stephens, J. V., electrical designer, Gibbs & Hill, Inc., New York, N.Y.

Woll, R. F., engineer, Westinghouse Electric Corp., Buffalo, N.Y.

27 to grade of Member



SUPERSONIC combat plane is flown by computer in major scientific advance in aerial defense against possible H-bomb attack. Hughes Aircraft Company test pilot, R. R. Carson, inspects prototype test model installed in F-102A, U. S. Air Force all-weather interceptor.

Major Scientific H-Bomb Defense Advance

AN AIRBORNE miniaturized digital computer that can fly a U.S. Air Force jet interceptor airplane, first defense against the airborne H-bomb, through all phases of supersonic combat, from take-off to touchdown, leaving the pilot free to make tactical decisions has become a major factor in United States scientific advance.

This "hardware" coming off the assembly line right now is Hughes Aircraft Company's new "Digitair," which was introduced recently at a meeting of writers and editors as the first airborne digital computer in actual production.

Computers in production for aircraft up to this time have been the analog type, it was explained. The digital computer, up to now regarded as necessarily a monster filling enormous rooms with equipment, has infinitely greater capabilities. The Digitair is small enough to fit into the cabinet of a 21-inch table model television set.

It can make 9,600 basic arithmetical computations in one second and render 6,250 decisions in one minute. It could compute all of New York State's 6 million federal personal income tax returns in 14 hours, or could "figure" all of New York City's gas and electric bills in 5.25 hours.

"Despite all the current furore about satellites and long-range guided missiles, there are no indications that these weapons will replace jet interceptors for aerial defense in the immediate future," J. H. Rubel, director of the Hughes Airborne Systems Laboratories, said. The best existing weapon for delivering the H-bomb is still the long-range jet bomber and the best defense against it is the jet interceptor. As speeds, range, and altitude of both increase, electronic control systems must become more and more sophisticated. Hence, the importance of a compact versatile digital computer.

Digitair is said to perform effectively all necessary computing functions associated with flight, navigation, search, and attack in an interceptor mission, thus enabling the pilot to concentrate almost exclusively on the vital tactical decisions involved in an atomic-age battle in the sky.

The computer has been in actual production for the past 6 months at the Hughes El Segundo, Calif., plant but could not be reported to the public sooner because of military security restrictions.

Security restricted the unveiling to newsmen of the display of a prototype test model. The production Digitair is designed for use in tomorrow's advanced jet interceptors.

Working with coded information flashed to it by powerful ground control stations and the airplane's own radar, the computer simultaneously takes in 61 different types of information while putting out 30 types. In so doing, it performs

or monitors 16 separate navigation and flight control functions during a program cycle of 1.8 seconds, all at least once, some of them several times, the report stated.

These include such operations as actuating the interceptor's control surfaces to correct pitch and roll; commanding the pilot to increase or decrease his speed; maintaining constant check on available fuel and the distance the airplane can fly on it under existing conditions; target range, azimuth, and elevation information provided to the pilot; proper speed and altitude the pilot should fly in order to intercept the target accurately; and a continuing check of its own accuracy and reliability.

"Digitair can solve more than one problem at a time. It can be working on a navigation problem while, at the same time, it is making calculations of wind directions and speed and dead reckoning on an enemy bomber," said Mr. Rubel. "The computer will decide at what point to intercept and at what altitude and will automatically fire the armament."

On October 5, 1955, Howard Hughes, flier-industrialist president of Hughes Aircraft Company, announced that his company was developing an advanced electronic armament control system which could fly Air Force all-weather interceptors completely automatically "from take-off to touchdown." A prototype model had been flying as early as 1953, it was stated, and now Hughes digital computers are chiefly responsible for making the predicted performance possible.

Not necessarily restricted to airborne military use, the new computer could be adapted to supersonic jet transports where it could automatically navigate and continuously compute speed and altitude for best performance. It could also automatically program fuel consumption from takeoff to landing, meanwhile considering varying flight conditions; automatically process and display navigation data; enable the pilot to insert alternate position, destination, and altitude information, and automatically control communications between ground traffic and automatic landing control."

One of the prime reasons for the success of Digitair as an integral part of the most modern airborne armament control system is its extreme light weight, only 120 pounds, made possible through new advances in miniaturization techniques.

"The computer contains 4,000 match-head-sized diodes—mostly made by Hughes—in place of various types of tubes which normally would be used," Mr. Rubel, said "and 75% of its 'wiring' is etched circuitry."

This provides additional tremendous savings in space and weight. Miniaturization contributes greatly to the reliability of the Digitair, as well. Extensive laboratory tests have proved that its computations are performed "to an accuracy of one part in 131,072 parts," Rubel revealed.

These additional facts about the first airborne digital computer in production were of interest.

1. Digitair has undergone more than 1,100 hours of tests in a *T-29* flying laboratory and in *F-102* all-weather interceptor test vehicles.

2. If the interceptor in which Digitair is installed is one of a number of flying airplanes, large or small, in a specific area, the computer will return the interceptor to its base after its attack in the proper landing order which has been assigned to it.

3. Installed in supersonic bombers, Digitair could automatically navigate, control target approach and bomb release, control communications, compute flight-control functions, direct defensive armament and escape maneuvers, and control evasive maneuvers.

4. Digitair is an extremely rugged computer. It was designed—and proved in environmental and flight test—to operate at temperatures varying from −67 F to +160 F, to withstand a shock of 15 g, to operate in frigid Arctic wastes or burning, sand-blown deserts.

5. The digital computer has a built-in self-testing unit which greatly simplifies operational maintenance. By opening a side panel in the forward section of an interceptor, a technician can gain access to a special test panel incorporating test dials and a small scope. Through use of dialing devices he can determine whether every portion of the entire electronic control system is functioning properly and if it is ready to carry out its mission. If not, he can immediately substitute complete "black boxes" to assure the mission's success.

6. In addition to performing 9,600 basic arithmetic calculations (addition or subtraction) per second, Digitair can handle 600 multiplications or divisions and 600 square root extractions in the same 60-second period.

7. While engaged in navigational operations the computer samples 33 analog and 28 digital inputs per second while computing 14 analog and 16 digital outputs. In other words, the Digitair samples 3,815 inputs and computes 1,610 outputs per minute.

8. Digitair will perform a total of 36,750 computations per minute.

Hughes Aircraft Co. Photo

PREFLIGHT check of Digitair is made by research engineer, R. D. Forest, during production of the digital computer that is about the size of a 21-inch table model television set. The 100-decisions-per-second computer will free pilots for tactical decisions by flying jet interceptor automatically throughout supersonic combat, from take-off to touchdown.

Efficiency Noted in Heat-to-Electricity Converter

DIRECT CONVERSION of heat energy into electric energy has been achieved in a unique electronic device developed at the General Electric (GE) Research Laboratory, it was announced recently.

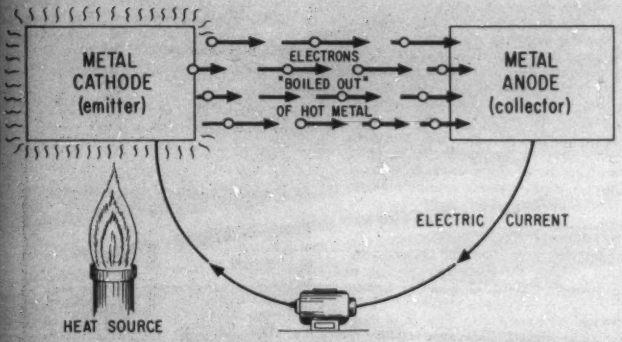
The new thermionic converter invented by Dr. V. C. Wilson takes advantage of the simple fact that electrons can be "boiled out" of a hot metal surface and used to produce an electric current directly. Experimental converters already have changed more than 8% of the applied heat energy into electric power.

"Dr. Wilson's work has opened the door to new understanding of how electricity can be generated directly from heat without using machines that have moving parts. The thermionic converter is strictly one of those results of research that should be judged for the knowledge it provides and not, at this time, as a commercial product," it was pointed out by Dr. Guy Suits, GE vice-president and director of research.

Science has been seeking simple ways to convert heat into electricity ever since the usefulness of electricity was first discovered, and Dr. Wilson's new thermionic converter is an extremely important scientific contribution, it was stated, but neither he nor the company wishes to imply that solar-powered space ships or inexpensive atomic power plants are just around the corner because of this invention.

"It is only natural," continued Dr. Suits, "to try to relate every new basic scientific discovery to some futuristic gadget. However, real research just doesn't ordinarily work that way. We cannot predict when—or if—the remaining scientific and economic problems inherent in direct heat-to-electricity conversion will be solved in a commercially acceptable manner. But we can point out the tremendous contribution which Dr. Wilson has made toward the solution of one of the age-old riddles of the electrical industry."

Thermionic converters combine several known scientific principles in a unique manner. Two electrodes within the tube-like device are maintained at high—but different—temperatures. New approaches to the design of the electrodes, the materials used, and the gas environment within the envelope have resulted in a more efficient flow of electrons than noted before.



THERMIONIC CONVERTER developed through new approaches to the design of the anode and cathode, the materials used, and the gas environment between them, which have smoothed the path of electrons and removed barriers that formerly absorbed the energy before it could be utilized in an electric circuit.

In a simplified explanation of his invention, Dr. Wilson says that when heat boils electrons out of the metal surface, it is analogous to lifting water to the top of a hill. "If we let the water flow down the hill, it can do work—run a water wheel, for instance—but only if we can provide the water with a smooth, uninterrupted path down the hill. The thermionic converter essentially smooths the path of electrons from a hot electrode to a cooler one, and removes barriers which in the past have absorbed the energy before it could do useful work in an electric circuit."

Most previous methods of converting heat directly into electricity—without rotating machinery—have been based on the thermocouple, a device long used by scientists for measurement and control functions. Thermocouples utilizing a junction of two different kinds of metal produce small electric currents when heated, but their efficiencies normally are well below 1%.

EXPERIMENTAL thermionic converter is inspected by Dr. V. C. Wilson, GE scientist, who invented the unit which converts heat directly into electric energy.

One obvious difference between the thermionic converter and the thermocouple is that in Dr. Wilson's device the metals are separated by a gas at very low pressure. There is an electrical flow between the electrodes, but there is less flow of heat than through a metal. Thus, the electrodes can be at different temperatures, and the efficiency is greatly increased. It is hoped that thermionic converters ultimately may be able to change more than 30% of heat energy directly into electricity.

Dr. Wilson, a 47-year-old physicist, is a member of the metallurgy and ceramics research department at the GE Research Laboratory. He distinguished himself early in his career as director of instrumentation and control for Dr. Enrico Fermi during construction of the first atomic reactor in Chicago, Ill., during 1941 and 1942. Subsequently, he has made important contributions to the study of ferrites and to the use of the neutron diffraction spectrometer as a tool for research.

During his explanation of the thermionic converter at a news conference, Dr. Wilson made particular note of the advice and counsel he had received from the late Dr. Irving Langmuir, Nobel prize winning scientist, and Dr. A. W. Hull, world-famous leader in vacuum-tube research and former associate director of the GE Research Laboratory.

It was emphasized that for nearly every vacuum-electronic tube device or system, there is a similar semiconductor method of accomplishing a similar electrical result. The semiconductor device corresponding to the thermionic converter is a thermojunction which, upon heating, will produce a flow of current and power in an external circuit. This same semiconductor junction may, by passing current through it, be used to produce heat when the current flows in one direction and to produce cold when the current flows in the opposite direction. The latter case is the "electronic refrigerator" which is under study. Some recent progress by scientists in these research areas were described and attention was called to the thermionic converter which represents "one of several promising investigations."

Company officials emphasized that thermionic converters are "experimental laboratory devices only" and are not considered ready for general production.

"It is a significant research step," according to Dr. J. H. Hollomon, manager of metallurgy and ceramics research for GE, "but we must increase the thermionic converter's efficiency and adaptability to a variety of conditions if it is to become a major new electric power producer."

Silicone-Insulated Motor Exposed to Radiation Source

A new field of practical nuclear research was opened recently when, for the first time, a silicone-insulated motor was deliberately exposed to a radioactive source. Culminating over a year's study of radiation effects on the physical and electrical properties of individual silicone materials, the motor test leads off investigations into the radiation effects on complete electrical insulating systems made by the Dow Corning Corporation, Midland, Mich.

The motor under test was a standard 1-hp, 182-frame, 1800-rpm, 3-phase, 440-volt, squirrel cage machine. It absorbed gamma ray energy at the rate of 0.1 megarads per hour. To further simulate actual on-the-job service in, for example, an atomic power plant, the motor was reversed every three seconds or so to maintain an operating temperature of 200 C. Additional tests are planned for a variety of silicone-insulated motorettes, capacitors, wire, cable, and electronic assemblies, many of which will be oven-aged at 200 C at the same time they are being exposed to the source.

How long will the motor last? It is predicted that experience with many types of silicones indicates that this motor should run at least 10 years. The cobalt-60 gamma radiation source and the linear accelerator beta radiation source have been extremely useful in tests on hundreds of different silicone fluids, resins, and rubbers which have absorbed from 2 to 2,000 megarads through the year. Their electrical characteristics have proved more stable than physical properties in almost every case. As a group, the resins are said to have exhibited by far the most resistance of all silicones to radiation.

Nuclear chemists interpret this data as confirmation of the tendency of radiation to attack the side-groups of a long-chain molecule, or polymer, promoting cross-linkage between molecules and consequent stiffening of the product. Because cured silicone resins are almost completely cross-linked already, radiation has little effect.

Silicone fluids, which have little or no cross-linkage, tend to jell on prolonged exposure. Silicone rubber, which has a degree of cross-linkage, hardens and loses resilience. However, it still remains useful in many applications where maximum flexibility is not required. Silastic-insulated wire has been found still serviceable after soaking up as much as 200 megarads.

A significant difference has been noted between electric properties measured during and those measured after radiation. During exposure, some properties appear to vary as the intensity of the source is varied. After exposure, however, total change in physical or electrical properties is primarily a function of the total amount of radiation the materials have absorbed.

Anticipating an increased interest in atomic power-plant construction in the near future, Dow Corning foresees a demand for engineering information regarding the reliability of equipment—from transformers to terminal boards—subjected to continuous radiation. Accordingly, the majority of all data obtained from these tests will be freely available to Dow Corning customers and prospects.

The program also enables Dow Corning to test out new materials designed for radiation resistance. The grease used in the bearings of the test motor, for example, is an experimental compound especially developed for the purpose.

Clocks, Sputniks, and Primary Standards

At the National Bureau of Standards (NBS) many types of investigations are constantly carried out. The three items mentioned have been investigated at the NBS Boulder Laboratories.

Clocks for Space Time. Although the stars make good clocks in space, a more modern and accurate time-keeping is of importance to man's conquest of space. This is one of today's facts that makes important the nation's precision time keepers.

At the NBS Boulder Laboratories, scientists have long worked to achieve and maintain time intervals which are precisely the same at all times. By referring to constant intervals one can measure the imperfections in all kinds of clocks. It is upon increasing accuracies the finer points of space travel and all the great modern developments in electronics depend.

For many years, the highly uniform vibrations of tiny instruments called crystal oscillators have been used as standards by the nation to measure frequencies and, consequently, time intervals because the frequency forms a very fine scale for any time interval needed. During the past few years, however, Government scientists have been experimenting with the vibrations of atoms as standards of frequency.

Their work indicates that theoretically an atomic oscillator may show an accuracy of one part in a *million* million, in comparison with the current standard which is correct to one part in a *hundred* million. In other words, the atomic oscillator may well prove to be 10,000 times more accurate than the crystal.

Such tremendously accurate timing has many fascinating implications for the future. For instance, science is now considering the possibility of assembling, piece by piece, space-platforms from which trips into the farther reaches of space might be launched with much greater ease than from Earth.

Boulder Laboratory scientists are studying a $50,000 commercially made atomic frequency oscillator which is a sort of electronic guinea pig because, for the next year or so, they will spend much time evaluating its performance to determine how it varies over a period of time. It is a 7-foot high panel of electronic equipment. The heart of it is a delicate $5,000 cesium-beam tube of short life expectancy —six months when used continuously. Although a metal, cesium melts when the temperature gets as high as 83 F. For this reason the section of the unit containing the cesium reservoir came packed in dry ice to avoid damaging the vacuum tube. The cesium atoms, like others, are known to vibrate at a phenomenally stable rate.

Because of accuracy and stability of frequency output, atomic standards will not only be useful to the launching of space platforms, but of immense values as electronic components and calibrators in navigation and communication systems and in research.

Primary Standards of Microwave Power. An unprecedented task fell to G. F. Engen of the Radio Standards Division of the NBS Boulder Laboratories and Dr. Denji Ishikawa, Japanese scientist, on December 5, 1957, when the national primary standards of microwave power of each of their countries were brought into agreement.

For this historical event, Dr. Ishikawa, a member of the Japanese national committee of the radio standards commission of the International Scientific Radio Union, hand-carried to the Boulder Laboratories, Japan's tiny but invaluable standard for power measurements.

This is the first time two countries have compared their national standards of radio power. In this case, the comparisons were made at 9375 mc and 10 milliwatts. As soon as possible, however, additional comparisons will be made at many other frequencies and power levels.

In scientific circles, this event is considered a step of the utmost importance to the future development of scientific research in the field of electronics where an internationally accepted standard of microwave power is essential.

The co-operation between two countries in making comparisons of their respective standards represents the beginnings of such a world-wide agreement.

This meeting between the Japanese and United States scientists is a result of the efforts of the International Scientific Radio Union which held its 12th Tri-Annual Assembly in Boulder this summer (1957). This organization is dedicated to

MICROWAVE POWER primary standards instruments of Japan (left) and the United States (right).

Future Meetings of Other Societies

American Society of Mechanical Engineers

Gas Turbine Power Division, Conference and Exhibit, Mar 2-6, Shoreham Hotel, Washington, D.C. Barry Freer, 1300 Connecticut Ave, NW, Washington 6, D.C.

Aviation Division, Conference, Mar 17-20, Statler-Hilton Hotel, Dallas, Tex. L. S. Dennegar, ASME, 29 W 39th St, New York, N.Y.

Committee on Management, Conference, Mar 19-20, Somerset Hotel, Boston, Mass. L. S. Dennegar, ASME, same.

Textile Engineering Division, Conference, Mar 20-21, North Carolina State U, Raleigh, N.C. L. S. Dennegar, ASME, same.

American Institute of Mining, Metallurgical, and Petroleum Engineers

Rocky Mountain Petroleum Sections, 4th Annual Joint Meeting, Mar 3-4, Cosmopolitan Hotel, Denver, Colo. H. N. Appleton, AIME, same.

Mid-Continent Local Section, Petroleum Production & Reservoir Engineering Conference, Mar 20-21, Mayo Hotel, Tulsa, Okla. H. N. Appleton, AIME, same.

Pacific Southwest Conference, Mar 27-29, St. Francis Hotel, San Francisco, Calif. H. N. Appleton, AIME, same.

The Society of the Plastics Industry

Canadian Section, 16th Annual Conference, Mar 6-7, Royal Connaught Hotel, Hamilton, Ont, Canada. L. P. Williams, SPI, 250 Park Ave, New York, N.Y.

Pacific Coast Section, 15th Annual Conference, Mar 26-28, El Mirador Hotel, Palm Springs, Calif. L. P. Williams, same.

1st National Lighting Exposition, Mar 9-12, New York Coliseum, New York, N.Y. Harold Meyer, c/o C. J. Wyle, Wyle Associates, Inc., 250 W 57th St, New York, N.Y.

ISA, Pittsburgh Section, 8th Annual Iron & Steel Industry Conference, Mar 11-13, Roosevelt Hotel, Pittsburgh, Pa. F. K. Briggs, 361 Tampa Ave, Pittsburgh 34, Pa.

Steel Founders' Society of America, 56th Annual Meeting, Mar 17-18, Drake Hotel, Chicago, Ill. G. K. Dreher, SFSA, 606 Terminal Tower, Cleveland 13, Ohio.

NACE, 14th Annual Conference, Mar 17-21, Civic Auditorium, San Francisco, Calif. A. B. Campbell, NACE, 1061 M & M Bldg, Houston 2, Texas.

IRE, National Convention, Mar 24-27, New York, N.Y. E. K. Gannett, IRE, 1 E 79th St, New York, N.Y.

Gas Appliance Manufacturers Association, Annual Meeting, Mar 31–Apr 2, The Greenbriar, White Sulphur Springs, W. Va.

Instruments, Electronics & Automation Exhibition, Apr 16-25, Olympia Hall, London, England. Industrial Exhibitions Ltd, 9 Argyll St, London, W1, England, or any U.S. British Consulate.

1958 British Electrical Conference, May 16-17, Palace Hotel, Brussels, Belgium. Sam Black, FIPR, 1958 British Electrical Conference, 36 Kingsway, London, WC2, England.

The Institution of Electrical Engineers, International Convention on Microwave Valves, May 19-23, Institution Building, Savoy Place, London, WC2, England. W. K. Brasher, IEE, same.

CIGRE, 17th Biennial Session, June 4-14, Paris, France. CIGRE, U.S. National Committee, 50 Church St, Rm 1777, New York 7, N.Y.

bringing about world-wide co-operation among scientists engaged in radio research and development.

Sputnik Measurements Data. Dr. F. W. Brown, director of the Boulder Laboratories released some facts which NBS scientists have gained from making and analyzing records of Sputnik II's trips around the earth.

The findings are based on data analyzed up to the afternoon of November 4, 1957, by R. M. Gallet. According to his calculations, Sputnik II is making a little more than 14 revolutions a day, taking about 103 minutes and 39.2 seconds (±0.4 second) to complete each revolution. Each revolution, it takes a fraction of a second less time to get around.

Because of air resistance, the satellite loses energy and continually falls closer to Earth. As the height of the satellite decreases, the speed increases and this keeps the satellite orbiting around the earth at a decreasing path length around the world thus continually decreasing complete revolution time.

Its orbit is very nearly a circle. Its eccentricity has been measured quite precisely to be 9.76%. Each trip around takes it as far as 1,026 miles away into space and as close as 140 miles from earth. When it crosses 40° N latitude (Boulder), the satellite will be about 146 miles high. The perigee, its closest approach to Earth, is about 50° N latitude. At these times, because it is close to Earth, it is traveling at its most rapid rate of 4.9 miles a second.

Each time the satellite goes around Earth, it is 26.2° further west. However, after making its 14 revolutions around the Earth it arrives about 12 minutes later and slightly west of its passage the previous day by approximately 5.7° longitude.

International Inventors' Exhibition

The Inventor's Exhibition, a noncommercial organization, is inviting all those that would like to exhibit their inventions to participate in the planning and showing of American Section of the 7th International Inventors' Exhibition. The group is organized with the express purpose of enabling inventors, patent owners, patent negotiators, and technical offices to get in direct contact with industrialists for the sale or negotiation of patents.

The Institut des Arts et Metiers in Brussels, Belgium, will be the scene of the exhibition as part of the 1958 World's Fair which will run from April through October. The specialized exhibition will take place June 6-29, 1958.

The deadline for submitting the participation applications has been set as April 1st. All correspondence must be in by that date.

The regulations are as follows:

Under the high patronage of the Minister of Economical Affairs, Foreign Minister, Minister of Public Education, Governor of the Province Brabant, Lucien Cooremans, Mayor of Brussels, of the Syndical Chamber for the Protection of Inventors and the highest Belgian and foreign personalities.

Article 1—All inventors, patent offices, companies or firms which own patented new inventions and all patent owners are allowed to participate in the 7th International Inventors' Exhibition which will take place during the Brussels World's Fair at which 30 million visitors from all countries of the world are expected.

Article 2—The inventions can be presented under the following forms: prototypes, rough models, commercial specimens, sketches or photographs.

Article 3—The inventions presented at the Exhibition will be classified in one of the following categories, and the Board of the Exhibition is the only judge of that classification:

Category A—Metallurgic industries, machines, and industrial processes and tools.
Category B—Wood industry, carpentry, cabinet work, tools and machines for wood industry, and home decoration.
Category C—Agriculture and fishing.
Category D—Building, public works, operation of building and materials, and heating.
Category E—Means of conveyance, automobile, motor-car, bicycle and accessories, marine and aviation.
Category F—Small tools and accessories.
Category G—Specialties of Parisian fashion, gift articles, and practical novelties.
Category H—Electricity, radio, television, telecommunication, accessories and tools pertaining to this category.
Category I—Optical apparatuses, glasses, photo and motion picture.
Category J—Clocks and watches, weapons, and music.
Category K—Household apparatuses, comforts of home and appliances.
Category L—Medicine, surgery, hygiene, orthopedy, and shoes.
Category M—Sports, touring, camping, games, and toys.
Category N—Commercial equipment, material, publicity, and office implements.
Category O—Pedagogy, graphical arts, and sciences.
Category P—Miscellaneous inventions presented under the form of sketches.

Article 4—To be accepted as a participant in the 7th International Inventors' Exhibition, it is necessary for the inventor to complete one application for participation per invention to be presented, as several inventions cannot be shown on the same application. An application, up request, will be supplied by Mr. Otto A. Witt, P. O. Box 1481, Milwaukee 1, Wis. The applications, duly completed and signed by the inventor, are to be returned to Mr. Otto A. Witt. No application will be accepted after April 1st, 1958.

Article 5—*Awards:* An international jury, composed of personalities competent in all above-mentioned categories, will examine each invention presented at the Exhibition. They will award the best inventions in each category diplomas such as the "Big Prize", "Invention Oscar", gold, vermeil, silver, bronze medals, etc. Those diplomas will be, for your future buyers, the best proof of the value of your inventions. Furthermore, they will be a solid basis for your publicity.

Article 6—The inventions destined to the International Inventors' Exhibition are free of customs duties and of all taxes in Belgium, provided they are re-exported to their countries of origin after the Exhibition. The transport charges from the United States to Brussels and vice-versa are entirely borne by the exhibiting inventors.

Article 7—Shipment of the inventions: All inventions, after they have been accepted by the Exhibition Board, are to be shipped between April 15th and 30th, 1958 *(neither prior to nor later than that time)*, to an American shipping agent, whose name and address will be given in due course by our Official Correspondent. That agent will take care, for the inventors, of all customs formalities and of the shipment of the inventions to Brussels. After the exhibition, that is to say beginning July 1958, all inventions will be reshipped to the United States through that American transport agent who will inform each inventor individually of the return of his invention. Each inventor will receive, in the course of March 1958, additional instructions concerning the shipment of his invention.

Article 8—Participation: *The inventor is not obliged to attend the exhibition personally.* If he does not attend it, all he has to do is to forward to the Exhibition Board a note explaining the operation of his invention, the advantages of the invention compared with existing apparatuses, its practical use, the price he wants to obtain for the sale of his patent or of licenses, whether he wants to find general representatives, etc. The Board will relay these details to the transaction service which will work free of charge during the exhibition. The transaction service will demonstrate the inventions in the absence of the inventors, give information to the visitors and note the names and addresses of prospective buyers, which information will be relayed without charge to the inventors.

Every possible step will be taken by the Board to expose the inventions in the most favorable manner and to keep in contact with the inventors if they receive commercial offers in connection with the inventions. Of course, the inventors are authorized to accompany and demonstrate their inventions personally. The will receive every possible assistance in Brussels

Article 9—*Participation Fee:* The participation fee is $50.00 per invention exhibited. This amount is to be transferred, at the same time as the application for participation, to Mr. Otto A. Witt, P. O. Box 1481, Milwaukee 1, Wis.

The $50.00 fee includes: (1) the entry; (2) the rental of space (as many square feet as necessary for a favorable presentation of the invention); (3) the fire-insurance premium; (4) the insertion of a short description of the invention in the official catalog of the Exhibition, 25,000 copies of which will be prepared; (5) the insertion of an advertisement of 1 x 4 inches under the heading Patents and Licenses for Sale in the official catalog of the Exhibition; (6) the collective publicity organized in favor of all participants; (7) the receiving of the invention; (8) the unpacking and placing on a counter, support, wall, or on the ground; (9) the decoration; (10) the preparation and placing, in front of the invention, of a presentation card explaining the invention in two languages, this card also mentions the name of the inventor and his nationality; (11) the services of translators and interpreters; (12) the transaction service described in article 8; (13) the lodging service who will reserve hotels and restaurants; (14) the mailing of a justifying catalogue to the inventor after the exhibition; (15) if the invention receives an award, the mailing of the prize-list and of the diploma awarded; (16) the relaving of mail which might be received in connection with the invention; and (17) the repacking of the invention which is transmitted, immediately after the exhibition, to the shipping agent for re-exportation.

Article 10—Electrical connections: An electrical connection can be put at the disposal of the exposers who apply for it at least one month prior to the opening date of the exhibition. The cost of that connection will be charged to the inventors in addition to the participation fee.

Article 11—*Publicity in Catalog:* 25,000 copies of the official catalog of the Exhibition will be prepared. That catalog will be sold during the Exhibition and copies will be mailed to the Embassies, Consulates, main business offices, Chambers of Commerce, etc.

This catalog is an excellent publicity medium and special advertisements can be accepted in it. The terms are as follows: entire page—7 x 4 inches: $60.00; half page—3½ x 4 inches: $40.00.

For that publicity, please contact Otto A. Witt.

Article 12—An important watch service will protect the inventions presented. However, the Exhibition Board refuses any responsibility in connection with the losses or thefts which might occur during the exhibition or in transport.

Article 13—The Exhibition Board consider that the receipt by them of the application for participation makes the participation final and that that participation can in no case be cancelled. Any case not provided for in the present regulation will be resolved without appeal by the Exhibition Board.

Automation Featured in Motor and Generator Manufacture

A 30% increase by 1961 in industry sales of electric motors and generators—one of the barometers of the nation's economy—was predicted by a General Electric Company (GE) executive recently.

J. M. Crawford, vice-president and general manager of the company's Motor and Generator Division, said he based the forecast on a "growing economy and a continuing trend toward automation."

He predicted that industry sales of motors from 1 hp up will rise from $670 million to $870 million in the next three years.

Speaking during a press showing of a new, highly mechanized motor factory for the production of 40- to 125-hp electric motors, he cited "uncertainties which have been troubling business and Government leaders in recent months," and said that the new facility demonstrates GE's "own faith in the future."

B. W. Wyman, general manager of the department, said that "less than a third of the motors required in the 40- to 125-hp ratings today are standards; the rest are specials." The design of the new facilities found an economical threefold answer to the manufacture of specials, as follows:

First, standardized parts which could be produced in volume and assembled in various combinations to meet a wide variety of motor requirements were designed.

Second, the facilities were designed at the same time as the product, thus enabling effective economies that would not have been possible otherwise.

Third, investing heavily in automatic materials handling equipment enabled the realization of important savings in this area.

The key to the rapid production cycle lies in the flexible design of the *Tri-Clad 55* (GE Registered Trade Mark) motors which permits the company to build and stock fully 80% of the parts for all motors, both standard and special. Delivery of standard motors is set at 2 weeks. Special or derivative motor delivery is from 4 to 6 weeks.

Motors, both old and new designs, in frame sizes 364 through 445 are being built in the new factory.

Actually, two buildings are involved in the production of these motors. The first of these buildings houses equipment which performs various automatic machining operations.

At this point, the components are picked up by a conveyor which carries them through an outside trestle connecting the two buildings.

After entering the second building, the conveyor travels overhead to "drop-off" points at various positions in the plant. At these points, motor frames, shafts, end-shields, etc., are picked off for assembly. The separation of machining and assembly insures against cast-iron dust getting into assemblies.

At the front of the building, mammoth punch presses stamp out rotor and stator punchings as sheet steel is automatically fed from 5-ton rolls into the presses. The stampings drop onto a belt and are carried under the floor and then up a vertical magnetic belt which carries them overhead to further operations.

After assembly into cores, rotors and stators are fed in batches into the annealing oven. Three separate chambers are contained within the 110-foot length of this oven: preheat, anneal, and cooling. All are "zone" controlled to help maintain maximum magnetic properties. Control settings are automatically altered as each batch enters the oven and travels through its three sections. The duty cycle of the oven can be preset to any production level. Maintenance on the furnace is low since the unit automatically greases itself when necessary.

Preliminary core-loss tests follow the annealing process and then the stator cores are automatically loaded and outside diameters turned to finish dimensions by newly developed equipment.

For maximum benefits, rotor cores travel through a "Parkerizing" process and then have aluminum windings cast by the centrifugal method.

Stator cores arrive at the coil insertion area automatically, assuring complete control of the production cycle. As workers finish the coil insertion in one core, another core automatically arrives at their work area thereby maintaining each day's schedule as previously determined.

Six successive insulation dip-and-bake operations are automatically performed on the finished core and cores are tested at this point. After the final baking, they are transported to a stator assembly machine. This unique equipment presses the stator into the frame with a force of 25 tons, assuring an immovable, distortion free fit on all frame sizes, both special and standard.

Final assembly is the vertical positioning of the rotor assembly into the stator and frame assembly. Less noise in bearings and efficient handling of parts is assured through vertical handling here.

Finished motors are shunted to test areas, where they undergo resistance, impedance, high-potential, surge, and sonic tests.

All parts travel in the same flow during machining and assembly. "Special" motors have their own process areas located throughout the factory to which they are detoured when their manufacture would interfere with the normal flow and manufacture of standard models.

Integrated data processing equipment is used in engineering for parts lists and production order origination as well as in order service for transmission to all factory points, scheduling, and subsequent shipping and billing operations.

The Frontiers of Science and Technology

The Soviet scientific advances in the conquest of space may have confronted the United States with the need for immediate and massive efforts to restore the balance, C. H. Greenewalt, president of E. I. du Pont de Nemours Company (Inc.), said recently. However, this must be done with the determination that it be temporary, and that the country shall return

STATOR ASSEMBLIES are pressed into frames under 25 tons of pressure in this specially designed machine which can accommodate all frame sizes that are manufactured at GE.

ROTOR AND STATOR blanks cling to magnetized belts as they are transferred overhead to indexing area from punch press on left which stamps them out from 5-ton sheet steel rolls.

as soon as possible to the pursuit of scientific progress on all its many and varied frontiers, he added.

Mr. Greenewalt was awarded the William Procter Prize for Scientific Achievement, one of the country's highest scientific honors. He made the joint annual address of the Society of the Sigma Xi and the Scientific Research Society of America at the annual meeting of the American Association for the Advancement of Science in Indianapolis, Ind., on December 27, 1957.

"The impact of the Soviet achievement has been startling and may well prove far-reaching," he stated. It already has put impetus behind a national program of scientific education, alerted the country to the need of adequate technology, and shown the dangers of overconfidence, he pointed out.

To the extent that these results are carried out intelligently, "our scientific progress will be benefited and our national position strengthened," Mr. Greenewalt declared. "Hasty expedients may, while promising immediate advantage, weaken rather than advance our long-range scientific endeavor."

"Science, like freedom, is indivisible," Mr. Greenewalt stated. "There has been no great advance that was not a synthesis of knowledge laboriously accumulated in many different disciplines—a co-operative fusion of many branches of knowledge."

In the long range, "real progress will be made only if all branches of science move forward together in an unbroken front," he said. And he advocated a broad rather than a specialized approach in filling the need for scientists by "intensifying our efforts in behalf of all education."

"The largest and most critical job to be assayed, however, is that which has its being in our national attitudes. At this time, when we are confronted with achievements which, to our shock and dismay, are not our own, it is a temptation to marshall our forces and undertake spectacular enterprises designed to recapture our reputation before the world. I sincerely hope that no scientific chauvinism will lead us down ill-considered pathways toward goals which may be more glitter than gold. Startling as the Soviet accomplishments in outer space have been, they represent, quite clearly, a concentration of effort, manpower, and brains on a single objective, achieved through the detriment of almost every other element of their society. We should not be provoked into similar patterns."

"American science," Mr. Greenewalt said, "is not a weapon, its edge sharpened for military aggression, but a plowshare tilling the peaceful fields of our normal lives. It has been well demonstrated that our capacity to produce in time of peace is our greatest weapon in time of emergency or war."

"We have learned," he declared, "that sound progress is progress that rests on the free advance of human knowledge in all of its many interrelated disciplines. Herein, lies our strength, and I am certain that our scientific sinews are fully adequate to prevail in the long run, whatever short-term setbacks we may encounter."

The major lesson of the space experiments is that no nation has a monopoly on scientific effort, Mr. Greenewalt continued, commenting that, "if the truth were known, Sputnik would pay homage to the scientists of many countries, not the least of whom would be the Chinese of the second century who originated the principle of rocket propulsion." He noted, further, that emphasis in science has changed frequently over the years, "guided sometimes by progress, sometimes by discovery, sometimes by the demands of national security, often simply by chance."

A basic interdependence exists between "all intellectual pursuits," just as it does between all branches of science, Mr. Greenewalt continued. Any artificial method which would tend to divert potential talent from other fields to scientific work "would add little to the progress of science while impoverishing all other areas of human activity."

The nation needs more scientists but the way to get them is to intensify efforts *to improve all education*. If this is done adequately, we will get them without departing from basic principles, he said.

"I cannot agree that there is anything fundamentally wrong with our educational institutions," Mr. Greenewalt declared. "We have dedicated ourselves to the doctrine that education is one of the necessities of life. As we regard the process, the objective is not merely one of filling the ranks of the professions, but more importantly to create for a large segment of our population an understanding of the literature, philosophy, history, and science forming the foundation of our culture."

The primary function of any educational system "is to spread before our young people the entire array of human knowledge in sufficient detail to permit each young man and woman to choose freely the career to which they wish to devote their lives, and to make their best contribution to that career. On this premise, if young people enter our educational institutions in sufficient numbers, we can safely rely on the laws of probability and the inherent variability of human aspirations to provide us with competence in all vocations and professions . . . The ultimate choice of a career must, however, remain free."

The educational process must be "diverse as well as specific—in short, to have as many facets as there are divisions of human knowledge. If we do the job well, we will have scientists in sufficient numbers and with sufficient competence."

Awards and Appointments

NEMA. A. N. Gray, Baltimore, Md., development engineer of Western Electric Company, received the coveted Manufacturers Medal of the James H. McGraw Award for Electrical Men as a highlight of the general membership luncheon in connection with the 31st Annual Convention of the National Electrical Manufacturers Association. The presentation was made by A. F. Metz, Passaic, N.J., chairman of the board, The Okonite Company, and a past president of NEMA. The medal is given infrequently and only to those whose contributions to the electrical industry are considered outstanding in the opinions of a panel of impartial judges. Mr. Gray received his award for development of a process for extruding rubber for insulating wire. He has devised a new process in which the compound is handled and extruded at room temperature.

American Chemical Society. The following 12 outstanding chemists and executives were appointed to the Advisory Board: T. H. Coulter, Chicago Association of Commerce & Industry; Lawrence Flett, consultant; J. H. Forrester, Amoco Chemicals Corp.; T. L. Gresham, A. E. Staley Manufacturing Co.; J. E. Hull, Manufacturing Chemists Association; S. D. Kirkpatrick, McGraw-Hill Publishing Co.; H. A. Marple, Monsanto Chemical Co.; W. J. Murphy, ACS Applied Chemistry Journals; G. L. Parkhurst, Standard Oil Company of California; C. F. Rassweiler, Johns-Manville Corp.; E. H. Volwiler, Abbott Laboratories; and Donald Williams, The Dow Chemical Company.

International Federation of Automatic Control. Harold Chestnut of General Electric Co., one of the three United States delegates, became the Federation's first president. Other council members chosen for a two-year term were: A. M. Letov of the Union of Soviet Socialist Republics Academy of Science in the Institute for Automatics & Telemechanics, first vice-president; V. Brodia of France, second vice-president; G. Ruppel of West Germany, secretary; and G. Lehmann, also of France, treasurer. The president and all his vice-presidents can serve only two terms, but there is no limit on the number of times the secretary and the treasurer can be re-elected.

SPE. T. A. Bissell, appointed executive secretary, effective November 15, 1957, brings to his new assignment 21 years' experience as a key staff member of a sister engineering society—the Society of Automotive Engineers (SAE). From 1936 until 1942, Mr. Bissell was Technical Editor of the SAE *Journal*.

The Material Handling Institute. R. L. Fairbank, vice-president, Towmotor Corporation, Cleveland, Ohio, was elected president. Others elected were Eugene Caldwell, president, Baker-Raulang Co., Cleveland, to serve as first vice-president, and C. L. Fell, vice-president, marketing, of American MonoRail Co., Cleveland, as second vice-president. The officers were all elected to serve one-year terms. All three of the men have been active for several years in varied phases of this trade association which now includes 14 product sections.

NSPE. C. A. Dunn, administrative head of the School of General Engineering at Oklahoma State University, has been nominated for the office of president of the National Society of Professional Engineers. Six regional vice-presidents and a treasurer were also nominated by the 43,000-member society for the administrative year which begins in July 1958. The vice-presidential nominees are: H. A. Mosher, of Rochester, N.Y., Northeastern Region; J. B. McGaughy, of Norfolk, Va., Southeastern Region; L. E. Easley, of In-

dianapolis, Ind., Central Region; W. L. Hindermann, of St. Paul, Minn., North Central Region; N. E. Hull, of Houston, Tex., Southwestern Region; and H. B. Blodgett, of Reno, Nev., Western Region. R. B. Allen, College Park, Md., was nominated for the office of treasurer.

IAS. E. C. Wells, vice-president—engineering, Boeing Airplane Co., has been elected president of the Institute of the Aeronautical Sciences for 1958. Also installed were 1958 Vice-Presidents Neil Burgess, manager, *J-79* project, General Electric Co.; Gen. B. W. Chidlaw, vice-president and director, Thompson Products, Inc., L. E. Root, vice-president and general manager, Lockheed Missile Systems Division; H. G. Stever, aeronautical engineering professor and associate dean, M.I.T. School of Engineering; and Treasurer R. D. Speas, aviation consultant, R. Dixon Speas Associates.

EEI. J. W. McAfee, president, Union Electric Company, St. Louis, Mo., has been elected president of the Edison Electric Institute, and J. E. Corette, president, The Montana Power Company, Butte, Mont., has been elected vice-president of the electric industry's trade association. Both were elected by the Institute's Board of Directors at its quarterly meeting.

Ultrasonic Welding of Various Types of Materials

At a recent joint meeting of the American Society of Metals and the American Welding Society chapters in Washington, D. C., a paper was presented by J. B. Jones, president of Aeroprojects Incorporated, West Chester, Pa., entitled, "Ultrasonic Welding of High-Temperature and Corrosion-Resistant Materials."

The following paragraphs are a summary of the presentation.

THE HISTORY of ultrasonic welding orginated and developed by Aeroprojects during the past 5 to 8 years was summarized. Graphs were presented showing progressive improvements in this vibratory welding process since 1954, when only 0.010-inch *1100-H14* aluminum could be joined to meet the strength requirements of *MIL-W-6860*, and none of the structural aluminum alloys in any gage could be welded to meet this specification. At present, ultrasonic welds of adequate strength can be produced in *1100* aluminum 0.070-inch thick, and 0.060-inch bare and 0.060-inch Alclad structural alloys can be joined with strengths almost double those required in the military specification.

It was pointed out that ultrasonic welding is developing in the direction of accomplishing spot-type junctions in heavier and harder materials; of seamweld-making machinery to handle foil and sheet gages of various metals and alloys; making jewelry-like weldments as exemplified by vacuum-tube components, transistor assemblies, foil coils, and the like; and joining a variety of geometries of various sizes.

Mr. Jones emphasized that ultrasonic welding can be used to join the more exotic metals, such as molybdenum, niobium, tantalum, zirconium, titanium, Inconel, Inconel *X*, and *17-7 PH* stainless steel in sheet gages up to about 0.030 inch. Emphasis was placed on the fact that ultrasonic welding usually results in a high degree of internal deformation at the faying surfaces being joined without any particular external deformation.

It was furthermore stated that good bimetal junctions can be produced with such combinations as nickel to molybdenum, Kovar to nickel, nickel to steel, aluminum to stainless steel, stainless steel to titanium, zircaloy to stainless steel, tungsten to stainless steel and to low-carbon steel, etc. As illustrated in representative photomicrographs which were presented by Mr. Jones, such bimetallic joints are produced without formation of brittle intermetallics or metallurgical mixtures of unknown corrosion susceptibility that characterize the several fusion-type joining methods.

Program and Budget Established for IAEA

The most recent addition to the United Nations family, the International Atomic Energy Agency (IAEA), officially came into being on July 29, 1957, and its first general conference was held in Vienna, Austria, where the headquarters are being established, October 1-23. The calendar year 1957 thus marked the culmination of the work of the IAEA's Preparatory Commission and the emergence of IAEA as a completely independent and autonomous organization.

A number of major decisions were taken at the first General Conference. W. Sterling Cole of the United States was appointed as the first Director-General, and began his 4-year term of office on December 1, 1957.

The program and $4 million budget of IAEA were approved at this December meeting, as well as the scale of contributions, the relationship agreement with the United Nations, and the selection of Vienna as the permanent headquarters of the group.

A 23-member Board of Governors has been established including the 13 members designated by the preparatory commission in July 1957, and the additional 10 members of the governing board were designated by the general conference which followed.

A number of offers of assistance were received which include over 5 tons of U-235 and 200 tons of natural uranium, source materials sufficient for 20 reactors and valued at approximately $100 million.

In addition, several of the member states have offered over 100 fellowships for training personnel in atomic energy studies and the nuclear sciences courses.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, *Electrical Engineering* reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Illustrations should be submitted in duplicate, one copy and inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Women Engineers

To the Editor:

I note with interest the picture of two women engineers and accompanying caption on page 105 of the January 1958 issue of *Electrical Engineering*. It is good to know that the ladies are beginning to be heard from in the field of engineering.

The sweeping generalization attributed to Mrs. Bess M. Kirkland that "women . . . have more imagination than men, greater attention to detail, and better budgeting sense" does not do credit to its utterer's engineering attitude toward the need to have statements backed by provable facts.

A qualifying word such as "often" or "sometimes" would have improved the accuracy of the opinion considerably.

Yours very truly,

W. B. MANN (M '51)

(President, The Wolfe & Mann Mfg. Co.)

Grounding Electric Appliances

To the Editor:

With the advent of Technical Aid, UN, Asia Foundation, and the other very worthy organizations for the help and guidance of backward countries, America (United States) has played and is playing a very great part. One has seen and met so many of the technical personnel who have come out to Burma to set up technical schools and have seen the very fine results. This work is still going on. One has occasion to visit the new Technical Institution recently opened in Rangoon and truly it is a magnificent building. One could say something about the size, but perhaps that is well left alone.

One thing which struck me as very remarkable was the library, books on every conceivable branch of the engineering field, all American. I was led to ask the question, "Where are the technical books?" and this question was not asked in any spirit of levity. The person of whom I asked this question looked in amazement, thinking probably I had gone mad. When I explained that there were very few books which came anywhere near

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to the electrical systems of Burma, he began to see what I meant.

Recently I read one of the journals and an article dealing with grounding, and one point stood out predominantly—230 volts 3-phase, 110 volts single-phase. This I understand is common practice in the States and that most of the home appliances are 110 volts.

Again your systems of distribution are different in the kilovolt ratios. We have here, and will have in the future, ratios of from 132 kv/66 kv/11 kv to 400 volts 3-phase and 230 volts for lighting. There is no 110-volt supply.

Grounding is more important for systems employing 230 or 400 volts because of the high potential to earth, and while it does not follow that a person may die from a 230-volt shock, and not from a 110-volt, yet the chances are far less. Again the conditions of an Asiatic country are so different from a Western one: humidity percentage is high, working and ambient temperature is higher than normal and the fact that many dwellings have earth or stone floors makes it essential that proper and efficient grounding is carried out.

To return to the Technical Institution —I spoke of the number of technical books; now I must also speak of the instruments and apparatus. In very few cases were the instruments or appliances fitted with 3-core flexible cables. In other words, no provision was made for grounding and one has only to look at any American or Continental publication to see illustrations of appliances in which this factor is ignored irrespective of the destination to which the appliance may go, or be used.

Again we have regulations and rules governing the grounding of equipment and no installation is passed if the earth resistance is higher than 2 ohms. One does not need to tell engineers that a bad ground is worse than no ground at all, and yet one so often comes across installations where the ground wire is carelessly wrapped around a pipe which may be the pipe from a water tank and not even a rising main or from a spike driven into the ground showing a test of 20 or more ohms. It is the fault point which is so often ignored and where the trouble really starts.

No one denies that the fundamental rules and laws are universal and may be included in any textbook but one does hope that there shall be a revision of such textbooks to meet the necessary conditions of the countries to which or in which they may be used. Though the principles may be the same, it is one thing to discuss a circuit breaker for 180 kv or switch-gear for voltages used in one country but a different one when discussing 132/66/11 kv. Protection devices, instrument transformers, and tripping devices coupled with the different manufacturers are points to be considered in writing or preparing books for the overseas scholar. Certainly protection of life and property must be treated as essential and vital.

J. A. Hill

(Senior electrical inspector, Union of Burma)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ANNUAL REVIEW OF NUCLEAR SCIENCE, 1957. Edited by J. G. Beckerley and others. Annual Reviews, Inc., Palo Alto, Calif, 1957. 496 pages, 6¼ by 9 inches, bound. $7. The present volume, 7th in the series, contains reviews of advances, and of the literature on 12 topics. Two of the papers, approximately one fourth of the volume, deal with meson physics; the remainder, with such topics as radiochemical separations by ion exchange, high level radiochemical processes, vertebrate radiobiology (lethal effects and pathology), the collective model of nuclei, scattering of high-energy electrons, and measurement of nuclear spins and static moments of radioactive isotopes.

ATOMIC POWER, AN APPRAISAL. Published by Pergamon Press, 122 E. 55th St., New York 22, N.Y., 1957. 151 pages, 5½ by 8¼ inches, bound. $3.50. Contents of this volume are based on an informal panel discussion held by the International Bank for Reconstruction and Development. The participants, all leading world figures in atomic energy development, present a picture of the present and future potentialities of nuclear power in economic terms and its probable impact upon individuals and nations. To provide an introductory framework, the volume begins with a series of chapters devoted to the atom, atomic energy, radioisotopes, and related subjects.

AUTOMATION IN PRACTICE. By S. E. Rusinoff. American Technical Society, 848 E. 58th St., Chicago 37, Ill. 1957. 261 pages, 5¾ by 8½ inches, bound. $6.50. The treatment in this integrated survey is primarily in terms of particular processes rather than particular industries or products. Basic principles are discussed first: self-regulation, negative feedback, the theory of closed loop control systems, and other aspects. These principles are then given concrete application in the major types of control devices employed in the automated and semi-automated plant with emphasis on metal production.

EDUCATION FOR PLANNING: CITY, STATE, AND REGIONAL. By H. S. Perloff. The Johns Hopkins Press, Homewood, Baltimore 18, Md., 1957. 189 pages, 5¾ by 8½ inches, bound. $3.50. With rapid urbanization, the spread of industry, and pressures on water, land, and energy resources in various parts of the country there has come about an increased need for formal planning activities. The question of what constitutes an appropriate basis for the education of city and regional planners is raised in this book and an attempt is made at some tentative answers. The three essays included with these topics and, in addition, review University of Chicago experiments in these areas.

ELECTRICAL CONSTRUCTION COST MANUAL. By R. E. Johnson. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1957. 431 pages, 6½ by 9¼ inches, bound. $10. To reduce time necessary to prepare cost estimates for electrical installations, the author proposes a complete system built around the concept of unit assemblies. He establishes fundamental methods for installing electrical work in various types of construction, develops standard assemblies, sets up unit costs covering the material and labor for each assembly, and gives a detailed estimating procedure for applying the unit costs. A coding system is devised to simplify the application of this concept.

ELECTROMAGNETISM AND RELATIVITY. By E. G. Cullwick. Longmans Green and Co., 55 Fifth Ave., New York 3, N.Y., 1957. 299 pages, 5¾ by 8¼ inches, bound. $12.50. A book for advanced students dealing with various aspects of electromagnetism which have received little attention in existing texts; for example: the electrical effect of a rotating cylindrical magnet, if a conductor, and if a dielectric; the calculation of a second order emf in a moving circuit; magnetohydrodynamic waves; the laws governing the induction of currents in superconductors; etc. In the last chapters, the author proposes a new fundamental law concerning magnetic energy that corrects a well-known disharmony between accepted theory and the experimental verification of electron inertia in current circuits.

ELECTRONIC DESIGNERS' HANDBOOK. By R. W. Landee, D. C. Davis, and A. P. Albrecht. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1957. Various paging, 6 by 9¼ inches, bound. $16.50. Design data and fundamental information on electronics is presented in this handbook with somewhat more than usual attention to theoretical explanations, which are supplemented by design examples. Areas covered include vacuum tube fundamentals, computer and servomechanism techniques, and waveform and network analysis. In addition, attention is given to such rapidly developing fields as transistor fundamentals and circuit design, design of stabilized d-c amplifiers, and advanced regulated power supply design. There is an unusually thorough section devoted to receivers.

ELECTROSTATICS IN THE PETROLEUM INDUSTRY. Edited by A. Klinkenberg and J. L. Van Der Minne. Elsevier Publishing Company, Amsterdam, Holland, 1958, distributed by D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N.J. 191 pages, 8½ by 12 inches, bound. $7. Static electricity is a recognized hazard in the petroleum industry. This book discusses the ways in which static electricity is produced, explains the causes of explosions and fires, and describes the methods and results of research on the subject. Preventive methods are indicated; in particular, the use of antistatic additives.

ELEMENTS OF MAGNETIC TAPE RECORDING. By N. M. Haynes. Prentice-Hall, Inc., Englewood Cliffs, N.J., 1957. 392 pages, 6¼ by 9¼ inches, bound. $7.95. A comprehensive treatment of the subject. Part 1 begins with the theory of magnetism and electroacoustic fundamentals. Part 2 covers the recording, playback, and erasing processes, tape editing; and single, dual, and multitrack recording. Part 3 describes the apparatus, including basic maintenance and repair. Part 4 provides a systematic review of the circuits involved, arranged functionally, with full explanations and diagrams.

ENGINEERING PRECISION MEASUREMENTS. By A. W. Judge. Chapman & Hall, Ltd., London, England, fourth edition, 1957. 447 pages, 5½ by 8¾ inches, bound. 65s. This book provides a general survey of the more important methods of precision measurements employed in engineering workshops, and describes in detail some of the more widely used ones from the viewpoint of the user in the gauge room, inspection department, toolroom, and machine shop. For some cases, the principles upon which the instrument is based are given, and typical examples are described. New chapters in this edition cover slip gauges, surface finish, straightness and flatness measurements, interferometive methods, and advances in automatic gauging and work sizing.

GRAIN BOUNDARIES IN METALS. By D. McLean. Oxford University Press, 114 Fifth Ave., New York 11, N.Y., 1957. 346 pages, 5¾ by 8¾ inches, bound. $8. A study of grain boundaries in metals that attempts to correlate and classify the basic problems involved. It includes a great deal of numerical data useful in approaching the subject. Starting with theories about the structure of grain boundaries and their influence on microstructure, diffusion, fracture and behavior during plastic deformation, the book then continues with energies of grain boundaries, migration of boundaries, and special features of low angle boundaries.

A GUIDE TO GRADUATE STUDY. Edited by F. W. Ness. Association of American Colleges, Washington, D.C., 1957; distributed by the American Council on Education, 1785 Mas-

sachusetts Ave., N.W., Washington 6, D.C. 335 pages, 7 by 10¼ inches, bound. $5. A survey of facilities including schools of engineering, available to the person interested in securing a doctorate. Preliminary material touches on various aspects of graduate study such as choice of vocation, selection of graduate school, and costs. The main portion of the volume consists of a directory of graduate schools and pertinent information on admission requirements, fees, tests and averages, financial assistance, fields of study, and faculty and enrollment. The subject index includes entries under all branches of engineering.

HANDBOOK FOR WELDING DESIGN, VOLUME I. Edited by C. R. Harman. Published for the Institute of Welding by Sir Isaac Pitman & Sons, Ltd., London, England, 1956. 305 pages, 5½ by 8¾ inches, bound. 45s. A handbook devoted to the design of products fabricated in mild or low-alloy steels by the metal-arc welding process. Wherever possible, this information is based on the relevant British standards or other recognized equivalent. The first volume is intended to provide the designer of a welded assembly with the data necessary to design a product both economical and of standard quality. Included are choice of materials, properties of sections, classification of electrodes, types of welded joints, design of welds, typical assemblies, and welding costs.

HANDBOOK OF ELECTRONIC MEASUREMENTS. Edited by Moe Wind. Published by the Polytechnic Institute of Brooklyn, 1956; distributed by Interscience Publishers, 250 Fifth Ave., New York 1, N.Y. 2 vols., 8½ by 11¼ inches, bound. $15. This handbook presents a compilation of measurement methods, categorized according to frequency, from d-c to the microwave region. Complete descriptions and illustrations of necessary equipment are given, and orders of accuracy and physical magnitudes are indicated. The measurement of fundamental parameters is presented first: voltage and current, power, impedance, frequency, time interval, phase and field intensity. Subsequent chapters deal with specific techniques for the measurement of the characteristics of electronic devices: gain, bandwidth, noise figure, transient response, distortion, waveform, stability, modulation, spectrum analysis, and attenuation.

IDEAS, INVENTIONS, AND PATENTS. By R. A. Buckles. John Wiley and Sons, Inc., 440 Fourth Ave., New York 3, N.Y., 1957. 270 pages, 6 by 9¼ in., bound. $5.95. The fundamental principles and philosophy of patent and trademark protection are presented with a view to providing more effective protection and exploitation of ideas and inventions. It is primarily directed at the engineer and scientists engaged in research and development activities. The author discusses the principles underlying patents in all fields of technology and then gives specific applications in each area. There is a complete case history of a simple invention providing a guide for readers who have had no previous experience with the Patent Office or with patent attorneys.

INDUSTRIAL ELECTRONICS CIRCUITS. By R. Kretzmann. Philosophical Library, 15 E. 40th St., New York 16, N.Y., 1957. 192 pages, 6 by 9 inches, bound. $10. Typical examples of the circuitry of industrial electronic apparatus are described in the following areas: photoelectric control devices, counting circuits for various purposes, stabilizing circuits, switching and control circuits, amplifiers and oscillators, rectifying circuits and motor controls. Functions of the various circuit elements are described along with detailed information on actual component values. The present volume is a sequel to the "Industrial Electronics Handbook" by the same author.

INFORMATION SYSTEMS IN DOCUMENTATION. Advances in Documentation and Library Science, Volume 2. Edited by J. H. Shera and others. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y., 1957. 639 pages, 6 by 9¼ inches, bound. $12. This is a useful compilation of symposium papers covering most of the major systems of information retrieval now in use, and in many instances these systems are represented by case histories and specific applications which may be extended and adapted to other uses. The papers are divided into six major divisions: fundamentals in systems design, documentation problems in specialized fields, semiautomatic systems, systems using accounting or statistical machines, systems using computers or computer-like devices, co-operative information processing.

DER KONTAKTUMFORMER. By Erich Rolf. Springer Verlag, Berlin, Germany, 1957. 549 pages, 6¼ by 10 inches, bound. DM $67.50. The Electrical and magnetic aspects of the mechanical rectifier are treated in detail, covering principles, characteristics, and operation. Specific topics dealt with are switching, voltage regulation, shunts and base loads, short circuits and protection, losses and efficiency, installation, and testing. Calculations are fully explained with numerical examples, and a considerable bibliography is provided.

PRINCIPLES OF ELECTRICAL MEASUREMENTS. By H. Buckingham and E. M. Price. Philosophical Library Inc., 15 E. 40th St., New York 16, N.Y., 1957. 600 pages, 5¾ by 8¾ inches, bound. $15. Beginning with standard deflectional instruments, this comprehensive work continues with sections on potentiometer and bridge methods, instrument transformers, integrating meters, and power system measurements. In the electronic field appear methods using thermionic tubes, resonance and heterodyne methods, and the cathode-ray oscillograph. Space is also given to magnetic measurements, to measurement of some non-electrical quantities, and to systems, dimensions, and standards. Both theory and practice are covered.

PROCESS INSTRUMENTS AND CONTROLS HANDBOOK. Edited by D. M. Considine. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N.Y., 1957. Various pagings, 6¼ by 9¼ inches, bound. $19.50. A thorough and systematic treatment of the operating and design fundamentals of measurement and automatic control systems used in the process fields. Although specifically directed toward the process industries, the fundamental techniques described are applicable to nonprocess fields such as medical, military, and aircraft instrumentation. Among areas covered are measurement standards, primary elements, measurement systems, indicators and recorders, automatic controllers, electric and pneumatic telemetering, fundamental principles of process control, and mathematical techniques for solving automatic control problems.

PUBLIC ADDRESS AND SOUND DISTRIBUTION HANDBOOK. Edited by A. J. Walker. George Newnes, Ltd., London, England, 1956; Transatlantic Arts Inc., Hollywood, Fla. 160 pages, 5½ by 8¾ inches, bound. $5. A practical guide to the planning, installation, and maintenance of electronic sound amplification equipment. Beginning with the theory of the amplifying tube and the factors which govern the power output of an amplifier, the author proceeds logically through amplifier circuits, microphones, loudspeaker equipment, etc., to detailed planning of sound systems, long-distance telephonic relays, and a variety of typical installations, including sterophonic sound.

RADIATION EFFECTS IN SOLIDS. By G. J. Dienes and G. H. Vineyard. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y., 1957. 226 pages 6¼ by 9¼ inches, bound. $6.50. The study of radiation effects in solids, particularly metals, is currently being extensively pursued. The authors here survey the present state of knowledge dealing, however, mainly with the physics of the subject, and considering only x-ray energies and higher. A fundamental treatment, the book discusses the interaction of radiation with matter, reviews basic experiments, describes the nature, properties, and annealing (diffusion) of the defects, and various special topics.

SAFETY ASPECTS OF NUCLEAR REACTORS. Edited by C. R. McCullough. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N.J., 1957. 237 pages 6 by 9¼ inches, bound. $8.50. Composed of key papers from the Geneva Conference on the Peaceful Uses of Atomic Energy, the material has been carefully selected, edited, and grouped under the following headings: normal reactor and chemical plant operation, development of radiation safety criteria, reactor accidents and their consequences, supercritical reactor experience. Because little has been available on the subject, this is a useful contribution in an area that will assume more importance as the power reactor program is developed.

SOLID-STATE PHYSICAL ELECTRONICS. By Aldert van der Ziel. Prentice-Hall, Inc., Englewood Cliffs, N.J., 1957. 604 pages, 5¾ by 8¾ inches, bound. $13. This volume presents a comprehensive introduction to the physics of solid-state devices now being used or developed in the electronics industry. The operation of metal-semiconductor diodes, p-n junction diodes, transistors, piezoelectric and ferromagnetic devices, etc., is presented in terms of the physical phenomena which make them possible. Little emphasis is placed on circuitry except where required to clarify the operation of the solid-state device.

SOVIET EDUCATION FOR SCIENCE AND TECHNOLOGY. By A. G. Korol. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1957. 515 pages, 6 by 9¼ inches, bound. $8.50. A general outline of the educational system of the Soviet Union from elementary through graduate school. A considerable portion of the book is devoted to the Technicum and other specialized schools which train students for work at the subprofessional level, and there is an extensive study of Soviet undergraduate higher education, with curricula in physics and a typical major in mechanical engineering shown in detail. The author's conclusions are at variance with some of the accepted generalizations concerning Soviet education.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

HOW TO READ SCHEMATIC DIAGRAMS. This 160-page book by David Mark is intended for elementary and high school students becoming interested in electronics, experimenters, hobbyists, beginning technicians, and industrial upgrading programs designed to acquaint personnel with electronic symbols and diagrams. The book presupposes no prior knowledge of electricity or electronics. It explains the basic theory appropriate to the subject, symbolism, technical notations, and organization of schematics in pictorial diagrammatic form. The reader is carried through the text on a progressive basis, being taught how to recognize symbolized as well as pictorial and schematic representations of electronic components. Standard Institute of Radio Engineers and industry accepted symbols are used throughout. Items such as batteries, lamps, switches, relays, fuses, transformers, capacitors, motors, generators and resistor vacuum tubes, metallic rectifiers, and a host of other electronic components are explained. Available from John F. Rider Publisher, Inc., 116 W. 14th St., New York 11, N. Y., price $3.50.

HUMAN RELATIONS IN INDUSTRIAL RESEARCH MANAGEMENT. Edited by R. T. Livingston and S. H. Milberg. Based primarily on the proceedings of the Sixth and Seventh Annual Industrial Research Conferences, this volume brings together—with integrating introductions—27 papers on the human aspects of organized research. Among other things, the papers analyze the nature of research management jobs, the role of the manager, and the individual, social and cultural factors that affect the processes of organization and management in industrial research. In Part I, the papers explore the basic concept of a job in an attempt to see the jobs of research organizations from all sides. In Part II, they examine the elemental system of man and job in industrial research, and they describe the expectations of the organization. In Part III, they consider the social properties of research groups, and they analyze the job of managing in research. In Part IV—together with the transcript of a

discussion panel—they study the important question of human relations in industrial research. In Part V, they examine some techniques used by research managers in order to improve human relations. 464 pages, price $8.50. Order from Columbia University Press, 2960 Broadway, New York 27, N. Y.

PART I—REACTOR SAFETY CONFERENCE. Four papers presented at an industry–Government conference on nuclear reactor safety held in October 1957 have been published by the U. S. Atomic Energy Commission (AEC) for sale by the Office of Technical Services (OTS), U. S. Department of Commerce. The two-session conference was held in New York, N. Y., under sponsorship of the American Nuclear Society, the Atomic Industrial Forum, and the (AEC). Four of the five papers read at the first session are contained in the publication. Two of the published papers, "AEC Licensing Policies and Procedures with Regard to Reactor Safety" and "Technical Requirements for an AEC Safeguards Report," deal with what an applicant must do to get a permit to build and operate a reactor. The third, "AEC Reactor Safety Experimental Program," describes the AEC's continuing work toward solving safety problems. The fourth paper discusses the role of the Advisory Committee on Reactor Safeguards, which is charged with evaluation of reactor hazards and review of proposed standards of reactor safety. The publication, *TID-7549*, may be ordered from OTS, U. S. Department of Commerce, Washington 25, D. C. It contains 44 pages, price 75¢.

METHODS FOR EMISSION SPECTROCHEMICAL ANALYSIS. October 1957. This second edition brings up to date the first extensive compilation of emission spectrochemical methods published by American Society for Testing Materials in 1953. It covers the spectrochemical analysis of the most important ferrous and nonferrous metals and alloys, as well as several nonmetallic materials such as slags, ceramics, caustic liquor, petroleum products, etc. Suggested practices are included on the installation and safe operation of a laboratory, specifying excitation sources, designating shapes and sizes of electrodes, sampling, and computations. More than 800 spectral line pairs, tested in continuous laboratory applications, are provided. In addition to the 65 suggested practices and methods, there are 16 recommended practices and tentative methods. This compilation presents the pertinent information for each method to permit its application in various laboratories and with different types of equipment. Each of the methods follows the same form of presentation so that similar steps in different procedures will be found in corresponding labeled sections under each method. Particular emphasis has been placed on specifying spectral exposure conditions, excitation conditions, and analytical pair data. Copies of this 504-page book may be obtained from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., at $7 each.

POWERING TRANSISTORIZED ELECTRONIC DEVICES WITH RADIATED ENERGY (U). L. R. Crump, Diamond Ordnance Fuze Laboratories, Ordnance Corps, U. S. Army. February 1956. 13 pages. (Order *PB 131264* from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., 50¢.) This report describes the principle and circuitry for powering electronic devices entirely from electromagnetic energy radiated from distant sources. The energy sources may be transmitters operated specifically for powering the devices, or ordinary commercial radio or television stations in urban areas. In most applications of the system, d-c power derived from received r-f energy is used to power transistors in various circuits. The report emphasizes the use of a transistor amplifier in the system to provide remote switching of power to a load. Complete instructions are given for construction of a standard broadcast radio receiver operating on this principle. Circuit arrangements are described for storing d-c power, withdrawing the stored power at selected rates and amplitudes, changing d-c power to a-c power, and applying the required power to various devices.

GRAY IRON CASTINGS HANDBOOK. Published by the Gray Iron Founders' Society, Inc., this is the first complete handbook ever written on gray and ductile iron castings. This 620-page comprehensive guidebook contains in one up-to-the-minute volume, information on how successfully and economically to design, purchase, and use gray, ductile, white, and high alloy iron castings. It contains 411 illustrations and graphs, 64 tables, and extensive bibliographies after each chapter, as well as a glossary of foundry terms and an index. The design engineer, buyer, production executive, heat treater, and management executive will find many helps for improving his products in this practical reference book. The broad scope of the handbook is readily discernible from the chapter headings. For example, there are sections on (1) the design of gray iron castings; (2) specifying and purchasing gray iron castings; (3) physical properties of gray, ductile, white, and high alloy iron; (4) heat treatment; (5) welding, joining, and cutting; (6) machining and grinding; (7) metallic and nonmetallic coatings; (8) functional and economical advantages of iron castings; and (9) a review of the history of gray iron. C. F. Walton, technical director of the Gray Iron Founders' Society, Inc., co-ordinated and edited the data supplied by engineering professors, outside research organizations, and other metalworking experts. The price is $10 per copy, postpaid. Copies can be obtained by sending remittances direct to the Gray Iron Founders' Society, Inc., Dept. P, National City–East 6th Bldg., Cleveland 14, Ohio.

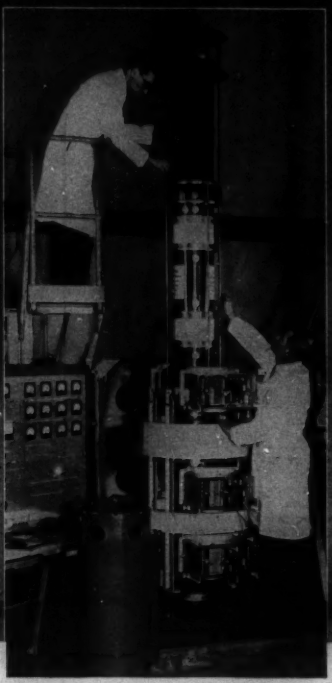
A GUIDE TO EFFECTIVE REPORT WRITING. A concise and practical guide to professional, technical, and administrative personnel who want to get their thoughts on paper faster, more easily, and more understandably is now available in this booklet published by Industrial Relations News. The Guide is designed particularly to meet the needs of personnel whose technical or professional training left little time for developing skill in effective communication, as well as for the secretary or typist responsible for turning out an attractive finished product. It discusses ways to construct a report, offers tips on clearer section, paragraph, and sentence structure, types of illustrative material, and provides examples of footnote style, correct punctuation, bibliography listing, and other aids to report writing, many of them illustrated by reproductions from actual company reports. The Guide contains detailed checklists covering each stage in the preparation of the report—assembling material, the writing process itself, reading and editing for content and style, proofing, layout, and typing. Available from Industrial Relations News, 230 W. 41st St., New York 36, N.Y., at $1.50 a copy.

ELECTROFORMING OF WAVEGUIDE COMPONENTS FOR THE MILLIMETER-WAVELENGTH RANGE. By A. A. Feldmann, National Bureau of Standards Circular 587, issued November 15, 1957, 16 pages, 15¢. (Order from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.) In the millimeter-wavelength range, electroforming represents almost the sole method of construction for precision waveguide components, due to the mechanical tolerances required. However, very few commercial electroplaters offer such services. This publication outlines the procedures and the materials necessary for the production of high-quality millimeter components with a minimum of equipment, time or specialized knowledge of electrodeposition. This can be done with machine-shop facilities, normal laboratory facilities, and a few auxiliary items. This circular includes sections on: metals to be deposited, the required equipment, the mandrel, cleaning process, masking of mandrels, and electrodeposition. A list of helpful literature and the title of a book containing sources of supply are appended. Foreign remittances must be in U. S. exchange and should include an additional one fourth of the publication price to cover mailing costs.

RULES GOVERNING THE SHORT-CIRCUIT TESTING OF AIR-BLAST CIRCUIT-BREAKERS FOR ALTERNATING CURRENT SYSTEMS. These Rules have been formulated by The Association of Short-Circuit Testing Authorities (Inc.) (ASTA) to secure uniformity in the short-circuit testing of air-blast circuit-breakers pending the publication of a British Standard. Until such a standard has been published the ASTA will issue Certificates of Short-Circuit Rating in the event of the circuit-breaker successfully passing the tests prescribed in these Rules. The publication of this document fills a long felt need for a uniform method of interpreting the results obtained and the assessment of the performance of the circuit-breaker. Problems other than those covered by this publication will undoubtedly occur from time to time and, as they occur, ASTA will have to make the decisions in each individual case, which will be recorded for future inclusion in these Rules. One very relevant problem is that of circuit severity, i.e., rate of rise of restriking voltage and amplitude factor. Until such time as values now under discussion have been agreed upon, this publication makes no attempt to prejudge the issue of circuit severities. In Clause 21, however, the publication provides that the inherent test circuit severity for each of the test duties shall be not less than the appropriate rated circuit severity assigned to the air-blast circuit-breaker. It is considered that this new publication will provide a useful guide to short-circuit testing stations and to all those interested or concerned in the testing of air-blast circuit-breakers. Price 10s, from The Association of Short-Circuit Testing Authorities (Inc.), 36 Kingsway, London W. C. 2, England.

ERGONOMICS: HUMAN FACTORS IN WORK, MACHINE CONTROL, AND EQUIPMENT DESIGN. Publication of Volume 1, Number 1, of this new periodical was recently announced by Academic Press Inc., distributors of the journal in the United States and Canada. The term "Ergonomics" is derived from two Greek words and means literally "the customs, habits, or laws of work." It was coined to denote an approach to the problems of human work and control operations which came into prominence during World War II in relation to equipment for the fighting services, and which since the war has been widely recognized as having important implications for industry. The development of radar and of high-speed aircraft, the elaboration of operation-potting rooms and of controls for ships, and the designs of clothing for extremes of temperature, all emphasized that technical developments had reached a stage at which the capacities of the user rather than the potentialities of his equipment were setting limits to the performance of men and machines working together. For progress to be made, it was therefore necessary that these human limits be studied and given due consideration. This new journal, of interest to physiologists, psychologists, anatomists, industrial medical practitioners, engineers, and managerial staffs of industry, will publish original research reports, review articles, letters to the editors, and abstracts of articles in other journals. The general editor of *Ergonomics*, the official publication of the Ergonomics Research Society, is Dr. A. T. Welford, Psychological Laboratory, University of Cambridge. The editorial board consists of H. Bastenier (Belgium); R. Bonnardel, Bernard Metz (France); E. A. Müller (Germany); M. G. Bennett, W. F. Floyd, W. E. Hick, C. L. Evans, and L. G. Norman (Great Britain); F. H. Bonier (Netherlands); S. P. M. Forssman (Sweden); E. Grandjean (Switzerland); and H. S. Belding, P. M. Fitts (U.S.A.). Volume 1, to consist of four issues, is priced at $13.50 per volume. The first issue, published in November 1957, contains articles by Eunice Belbin, R. M. Belbin, and Frank Hill; D. E. Broadbent; J. B. Collins and R. G. Hopkinson; J. R. de Jong; J. E. Karlin; R. A. McFarland; H. Scholz; R. S. Schwab. Subscription orders originating in the United States and Canada should be addressed to Academic Press Inc., 111 Fifth Ave., New York 3, N. Y. December 31, 1957.

ENGINEERS JOINT COUNCIL POLICY STATEMENT ON "AIR POLLUTION AND ITS CONTROL." Policy principles for consideration by those concerned with air pollution and its control, developed by the engineering profession through the Engineers Joint Council (EJC) are presented in this publication. Prepared by the EJC Air Pollution Committee, Report No. *107* is available at 5¢ per copy from Engineers Joint Council, 29 W. 39th St., New York 18, N. Y.



Eimac super-power klystron being lowered into circuitry in Eimac laboratory.

Eimac Klystron Produces Super Power For Missile Tracker

Development of the super-powered radar ballistic missile tracker, now in operation at the Lincoln Laboratory of Massachusetts Institute of Technology, required an electron tube that would produce tremendous amounts of RF energy at the desired frequency. Long experience in pioneering ceramic-metal power klystrons enabled Eimac to design a super klystron that efficiently and reliably produces the tremendous RF pulse power required for this application. It was built for Continental Electronics Manufacturing Company, the transmitter manufacturer, under sponsorship of the Air Research and Development Command's Rome Air Development Center of the United States Air Force.

Similar to the tube shown above, this super klystron is the largest electron tube in the world; even this ten-foot giant will soon be dwarfed by 17-foot Eimac klystrons now under development.

Equipment engineers throughout the world are finding that the uniqueness of Eimac klystrons makes the difference in simple, efficient and reliable equipment design for tropospheric scatter, commercial television, telephone relay and high power radar applications. Eimac today manufactures CW and pulse amplifier klystrons covering the spectrum into the X Band and to megawatts of power.

For further information on Eimac klystrons write our Application Engineering Department for a copy of Klystron Facts Case 4

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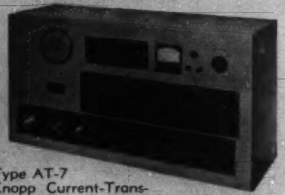
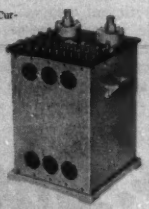


Type AT-7
Knopp Current-Transformer Testing Equipment, shown above, provides accurate calibration of instrument transformers having 5-amp secondaries, and having primary current ratings of from 5 to 1500 amps inclusive. A Knopp Precision Multirange Current Transformer is used as the standard of comparison.

The Knopp Current-Transformer Comparator features low burden combined with ease of operation, freedom from effects of stray fields, harmonics and overloads. Over-all accuracy is within 0.010 percent for ratio and 0.5 minute phase angle for secondary currents from 0.5 to 20 amps. It is used with a loading transformer with variable supply and a precision instrument transformer.

The Type CU Knopp Unload Current-Transformer Test Sets offer ultra-high accuracy for precision tests in laboratory and field on instrument current transformers. Type CU-500 provides 21 ranges from 5 to 500 amps; Type CU-5000 provides 19 ranges from 600 to 5000 amps. Secondary 5 amps. Knopp Unload Sets eliminate the need for many single-range standards and loading transformers. These are examples of the various Knopp custom-built equipment now available for testing instrument transformers. Your requirements for high accuracy and reliable test-results can be fulfilled to please you by Knopp specialized engineering. Write now and tell us your problems.



KNOPP INC.

Founded in 1928 by Otto A. Knopp under the name of Electrical Facilities Inc.

Dept. A-15, 1307 66th St., Oakland 8, Calif.

INDUSTRIAL NOTES

Ultramodern Offices. Fischer & Porter Company, 463 Jacksonville Rd., Hatboro, Pa., has moved into its new windowless, air-conditioned, ultramodern office building adjoining their Hatboro, Pa., plant. The latest techniques were used in erecting the two-story, 50,000 square foot structure, among them the "lift-slab" method by which concrete floors and roof are cast on the ground and then raised into position by hydraulic jacks. Three stained glass panels of abstract design relieve the monotony of the windowless walls. An exception to the windowless construction is the cafeteria which has floor-to-ceiling windows overlooking an outdoor roof patio.

Ramo-Wooldridge Subsidiary. An important increase in efficiency and a decrease in operating costs in many major industrial processes through application of modern techniques of electronic computation and control has been predicted by Thompson-Ramo-Wooldridge Products, Inc. which was newly formed in December 1957, as a wholly owned subsidiary of The Ramo-Wooldridge Corporation, 5500 W. El Segundo Blvd., Los Angeles 45, Calif., and Thompson Products, Inc., Cleveland, Ohio. The new company will concentrate its efforts on industrial process control, and market as its first major product the *RW-300* digital process control computer, developed in conjunction with The Texas Company, Port Arthur, Tex., petroleum refinery. The subsidiary will also undertake the development and study of other applications of digital computing techniques to business and industry. Thompson-Ramo-Wooldridge Products, Inc., offices will be located at the Ramo-Wooldridge Center near Los Angeles International Airport.

Alcoa. The commercial availability, for many applications, of aluminum alloy bus bars with guaranteed minimum electrical conductivity of 60% International Annealed Copper Standard, at no increase in price has been announced. It is designated as No. *2 EC-T61*. Since 1954, Alcoa has pioneered in raising the 55% the temper figure point by point, culminating in 60% for the *T61* temper. With all of these properties guaranteed, designers can effect, in many instances, a marked savings either in the form of smaller bus conductors or smaller power losses, or a combination of both. Contact Aluminum Company of America, 1501 Alcoa Building, Pittsburgh 19, Pa.

AEC Contract Renewal. The Atomic Energy Commission (AEC), P.O. Box 59, Lemont, Ill., has renewed a contract with United Aircraft Corporation for the development of nuclear propulsion for aircraft. The cost-plus-fixed-fee contract, originally entered into in May 1953, is extended to September 30, 1960. The ultimate objective of the work which is being performed by the Pratt & Whitney Aircraft Division of the United Aircraft Corporation is the completion of the engineering design of reactors suitable for use in an advanced aircraft propulsion system and the development of reactor components.

Cooling Unit Developed. A cooling unit that is packaged as an integral part of the airborne electronic equipment which it cools has been developed by The Garrett Corporation's AiResearch Manufacturing Division, 9851 Sepulveda Blvd., Los Angeles 45, Calif. This particular unit was designed to provide a net cooling capacity of 1.5 kw at 50,000 feet.

Expanded Scale Meters. A line of meters in which the scale is electronically expanded recently has been developed. By eliminating the unused lower portion of the scale and using the full scale to cover the range in which readings can be expected to fall, much more accurate readings can be obtained. For example, on a voltmeter used to measure values around 28 volts, the scale would be expanded to cover 26 to 30 volts and values from 0 to 26 volts would be eliminated. Reading accuracy of 0.25% of true voltage is possible because of the absolutely linear expanded scale. For further technical information, write to Miller Instrument Company, Inc., 165 E. Lincoln St., Escondido, Calif.

American Silver Company. Precious metals permanently clad to inexpensive base metals are now available in precision-rolled strip from the American Silver Company, 36-07 Prince St., Flushing 54, N.Y. They are finding wide use in the electronic, electrical, chemical, aircraft, instrumentation, automation, and related industries. Precious metals clad to inexpensive base metals include silver, gold, platinum, and palladium. Cladding is accomplished by the direct bonding of ultrathin layers of the precious metal to the base metal by means of heat and pressure. The resultant bonded structure exhibits the properties of both metals, becomes, essentially, a "new" metal.

Flexible Insulation Developed. A method of insulating pipes carrying high temperature fluids or gases has been announced. It consists of wrapping and bonding a woven ceramic fiber tape around pipes as small as ½-inch diameter with a zirconium-base cement. This combination forms a positive, shock resistant insulation that withstands temperatures to 2,000 F. Because of the relative narrowness of the tape, insulation can be quickly and easily applied even in restricted areas. A second layer of ceramic tape can be applied to complete the wrap-around insulation. Further information about Rusco woven ceramic tapes and insulating methods is available upon request to The Russell Manufacturing Company, 586 E. Main St., Middletown, Conn.

(Continued on page 20A)

here's how NATIONAL saved a steel mill time and money by changing the operating characteristics of a motor

A midwestern steel mill needed a 60-cycle motor to drive two generators which furnished D.C. power for a rolling mill. They had available a 25 cycle, 2300 V. motor rated at 5,000 HP, 375 RPM. When asked to convert this to the mill frequency, National redesigned and rebuilt it to 60 cycle, 4,000 HP, 12,000 V., 360 RPM—adequate for all requirements. Winding of the rotor is shown in photo above.

Where redesign can produce the change you need, it offers substantial savings over the cost of new equipment—particularly when you can take advantage of idle equipment you already own.

When time is a factor, redesign and rewinding can be completed in a much shorter time than it normally takes to get delivery on a new machine.

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Radio Engineering Products is currently producing a number of types of equipment, electrically and mechanically interchangeable with standard Bell System apparatus.

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C5 Carrier-Telephone Terminal (J68756). A kit for adding a fourth toll-grade channel to existing C systems is available. • C1 Carrier-Telephone Repeater (J68757) • 121A C Carrier Line Filter • H Carrier Line Filter (X66217C).

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V1 Telephone Repeater (J68368F) • Power Supply (J68638A1) • V1 Amplifiers (J68635E2 and J68635A2) • V3 Amplifier (J68649A) • V-F Ringers (J68602, etc.) • Four Wire Terminating Set (J68625G1) • 1C Volume Limiter (J68736C).

D-C TELEGRAPH EQUIPMENT

16B1 Telegraph Repeater (J70037B) • 10E1 Telegraph Repeater (J70021A) • 128B2 Teletypewriter Subscriber Set (J70027A).

TEST EQUIPMENT

2A Toll Test Unit (X63699A) • 12B, 13A, 30A (J64030A) and 32A (J64032A) Transmission Measuring Sets • 111A2 Relay Test Panel (J66118E) • 118C2 Telegraph Transmission Measuring Set (J70069K) • 163A2 Test Unit (J70045B) • 163C1 Test Unit (J70045D).

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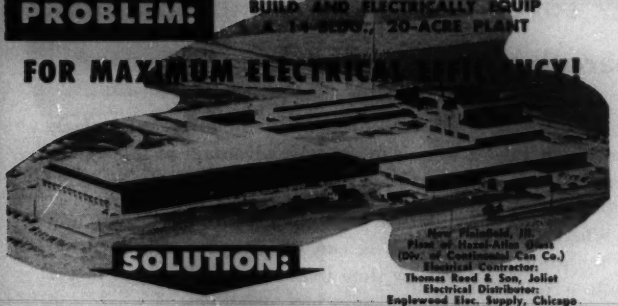

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Industrial Notes

(Continued from page 18A)

Package Conveyor Belting. A cross-corrugated belt, designed for inclined package conveyors and particularly suited for use on steep inclines, has been announced by New York Rubber Corporation, 100 Park Ave., New York 17, N. Y. The ribs in the new "Ridgetop" package conveyor belt are so flexible that they deflect under load and provide a firm non-slip grip on packages moving up inclines at angles of up to 45°. "Ridgetop" conveyor belting is offered in widths up to 48 inches. Variations in construction to meet special requirements are available in orders for reasonable quantities.

Nuclear Reactor Agreement. The Siemens organization of West Germany, Europe's largest electrical manufacturer, has signed a technical assistance agreement to build and sell full-scale atomic power plants under license with Westinghouse Electric Corporation, Box 2278, Pittsburgh, Pa., and its subsidiary, Westinghouse Electric International Company. Under the licensing arrangement, Siemens will build non-military types of nuclear reactors developed by Westinghouse.

Weather-Resistant Polyethylene. A polyethylene plastic to be specifically compounded with an ultraviolet inhibitor for use in molding or extruding outdoor products has been introduced. This polyethylene compound, in natural or colors, incorporates a newly developed ultraviolet inhibitor. It will last two to four times longer outdoors than polyethylenes that contain no inhibitors to protect them from the sun. A new Tenite polyethylene formulation, the compound is now available in commercial quantities from Eastman Chemical Products, Inc., Subsidiary of Eastman Kodak Company, Kingsport, Tenn.

Company Enters Slip Ring Field. Electro-Contacts, Inc., Osterville, Mass. is now in production on precision brush blocks, slip rings, switches, and complete assemblies of precision devices. The Osterville plant includes complete, modern facilities for the design, development, and manufacture of precision electromechanical contacts. The company is currently in production on slip rings, slip ring assemblies, several types of switches, and brush and brush block assemblies.

Industrial Products Division Established. Establishment of a special Industrial Products Division for the production of special-duty transformers has been announced by Hill Transformer Co. Inc. Types and sizes will be produced for all industrial applications, with designs developed to individual specifications and units built to National Electrical Manufacturers Association and American Standards Association standards. Hill also manufactures power and distribution transformers up through 5,000 kva. Main offices are at 1030 Washington St., San Carlos, Calif.

An improved Combination Starter for extra safety

While the changes in the new Allen-Bradley Bulletin 712 and Bulletin 713 starters may be relatively minor, they were made in your interest—to give you the best control on the market.

The new operating lever has been attractively restyled and structurally improved. Now the disconnect switch can be locked "open" or locked "closed"—with three padlocks of any kind. For the maintenance engineer, a concealed latch pin is built into the lever, which permits opening the door of the cabinet without opening the disconnect switch and stopping the motor. The door can also be padlocked shut independently of the operating lever.

With the disconnect lever in the "off" position, the cabinet door can be opened. At a glance, it can be seen that the movable contacts are open. An added "safety" feature—the incoming line connections are covered with an insulating plate to prevent accidental contact.

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NEW PRODUCTS

Molded Transformers with Epoxy Resins. A line of molded transformers using epoxy resins, Type *CPE*, for indoor or outdoor metering applications has been introduced. According to the manufacturer these units are recommended for use with watt-hour meters or other applications where exceptionally high accuracy at low burdens is required. The units are interchangeable with current transformers, meeting dimensions of Edison Electric Institute meter and service committee specifications for 600-volt transformers. They meet all other association accuracy standards. The *CPE* is a window type transformer, but can be supplied with round or flat bar primary conductors, also with mounting brackets for switchboard use. Write to Standard Transformer Company, 143 Dana St., Warren, Ohio.

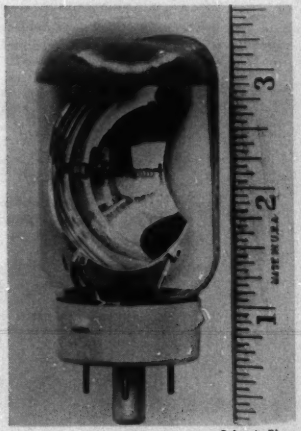
Anti-Static Cleaning Devices. Two types of static eliminating equipment, specifically designed for cleaning dust and dirt from plastic parts, plastic and paper sheets and films, textile materials, rubber, leather, and all other types of surfaces to which the dust is being attracted and held electrostatically have been announced. In the new static bars, provision is made for simultaneously blowing off the dirt and neutralizing the static charges on both the dirt and the part being cleaned. This simultaneous action is much more effective than other cleaning methods such as brushing or wiping, because not only is the dust completely removed, but also the electrostatic forces tending to reattract it to the part are eliminated. For further information contact The Simco Company, 920 Walnut St., Lansdale, Pa.

Square-Face CRT. A 3-inch square-face cathode ray tube for oscilloscope and instrumentation requirements has been introduced by Resitron Laboratories, Inc., designers and manufacturers of camera pick-up, X-ray, high voltage rectifiers, and special purpose electron tubes. This 3-inch cathode ray tube is electrostatically focused and deflected and presents a pictorial area comparable to a 3-inch round tube with 3-inch circuitry. It is available in all types of screens. Data sheet and prices on this cathode ray tube may be had by writing to Resitron Laboratories, Inc., 2908 Nebraska Ave., Santa Monica, Calif.

Versatile Photocopier. The Contoura-Constat photocopier for engineers makes photo-exact copies of drawings, specifications, blue prints, research data from magazines and books, reports and charts, deeds, confidential and technical data. It may be used on either a-c or d-c current and needs no special wiring. Precision engineered for size and weight, it comes in three sizes: the research size measures 11 inches by 13½ inches and weighs 22 pounds; the legal size, 11½ inches by 17 inches, weighs 26¼ pounds; the magna size, for general office use measures 17 inches by 22 inches and weighs 31 pounds. Made of nonbreakable gray plastic it can be operated by anyone to make fine quality copies of anything written, drawn,

or printed. It copies red and all colored inks, ink stamps, pencil, crayon, mimeograph, and even spirit duplicator. For further information contact F. G. Ludwig, Inc., 216 Coulter St., Old Saybrook, Conn.

"Tru-Flector" Lamp. A revolutionary type of electric lamp, with a built-in reflector and sharply focused beam that makes it resemble a miniature lighthouse beacon, has been introduced by Sylvania Electric Products Inc. The lamp is no larger than a standard flashlight battery. Although immediate application of the new lamp, known as the "Tru-Flector," will be in motion picture projectors, there are many



Sylvania Photo

other potential uses for the new device in such fields as automatic controls, infrared heating, and microscopy illumination. Specifications are as follows: 150 watts, 115 volts, coiled coil, horizontal, filament, 15 hours rated average life, base down burning position, and 95 screen lumens minimum, lumen rating. For further information contact Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N.Y.

(Continued on page 24A)

CONTROL PANEL for a 3 phase Electric arc furnace—type HF (hydraulic) regulator.

BENCH BOARD TYPE CONTROL for 3 phase arc furnace—type SIMPLEX (electro-mechanical) regulator.

CURRENT REGULATOR Element for DC electric arc furnace—transductor type TRANSEX, for an aluminium plant.

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New Products

(Continued from page 22A)

Subminiature Indicator Lamps. Production availability of the "Litestrip," representing a new idea in indicator lamp assemblies has been announced by the Circon Component Corporation. The Litestrip essentially is a preassembled and pretested strip of 10 indicator lamps bearing numerals from 0 to 9. The unit thus forms a complete decade ready for assembly into computers, annunciators, matrix, and read-out applications at a cost less than that of installing individual lamps. When used with the *NE2C* subminiature neon lamp Litestrip power consumption is infinitesimal in normal use at only 0.04 watts. Current drawn is extremely low at 0.003 amperes. Practically no heat is produced and average lamp life is over 25,000 hours. All lamps are replaceable. For further information write to Circon Component Corporation, Santa Barbara Municipal Airport, Goleta, Calif.

Versatile Unbreakable Fixture. Especially designed to be proof against vandalism and violent handling, the "Ruby Security" fluorescent light fixture has many applications in schools, hospitals, institutions, and municipal installations. The fixture fits flush against ceiling or wall and its sturdy plexiglas lens can resist virtually any human attack upon it. It can be opened for relamping only with a special tool. When closed, the fixture is dustproof and bugproof. Completely waterproof, it can be washed down with a hose at full pressure. Available in units to carry two, three or four fluorescent lamps, the rapid-start lamps can be changed in two minutes. It is finished in white baked enamel. Ruby Lighting Corp., 802 W. Whittier Blvd., Whittier, Calif.

Exceptionally Flexible Control Cable. Development of a control cable that offers the extreme in flexibility has been announced. This 42-conductor, No. *24* gage, Vinyl insulated cable is color coded and has a nylon braided jacket. The Rex Corporation's engineering staff is available for consultation on difficult wire and cable problems. For complete information write directly to manufacturer, The Rex Corporation, West Acton, Mass.

Manual Starter. Now available is a completely new line of Class *2510* integral hp manual starters, in National Electrical Manufacturers Association Sizes 0 to 1, for control of motors up to 7½ hp. This design features a heavy-duty, toggle action operating mechanism which gives positive snap-action opening and closing of the contacts, with no dead center position. Rated up to 600 volts a-c or 250 volts d-c, these starters are available in compact 2-, 3-, or 4-pole construction. In addition to an open-type version, a complete line of newly styled enclosed models is offered to meet a wide range of application requirements. For complete information, write Square D Company, 4041 N. Richards St., Milwaukee 12, Wis.

(Continued on page 26A)

HALF the world is half asleep! Men who could be making *twice* their present salaries are coasting along, hoping for promotions but doing nothing to bring themselves forcefully to the attention of management.

They're *wasting* the most fruitful years of their business lives . . . throwing away thousands of dollars they may never be able to make up. And, oddly enough, they don't realize—even remotely—the tragic consequences of their failure to forge ahead while time is still on their side.

Engineers and other technically-trained men are particularly prone to "drift with the tide" because their starting salaries are reasonably high and promotions come at regular intervals early in their careers. It isn't until later—too much later in many cases—that they discover there is a definite ceiling on their incomes as technicians.

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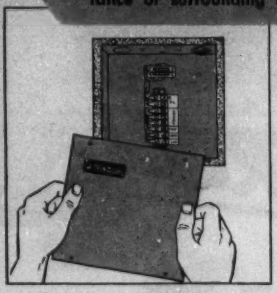

GTC completely eliminates the need for costly, space consuming central control panel equipment and complicated wiring. Just two pairs of unshielded wires run between stations. The inconvenience and expense of vacuum tube failure is now a thing of the past.

GTC Handset Stations and Loudspeaker Amplifier Assemblies may be installed and field-wired anywhere. Merely "plug-in" amplifier units when ready to use. Installation, maintenance and expansion costs are drastically reduced.

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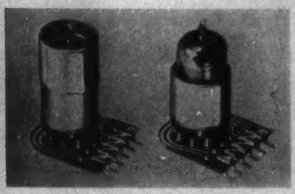
New Products

(*Continued from page 24A*)

Right-Angle Socket Tube Shield. This shield has been incorporated into the right angle *7 PC-IS* and *9 PC-IS* series sockets produced by the Cleveland Metal Specialties Company. As an integral part of the entire assembly, the tube shield cannot be lost or misplaced when servicing the socket or installing a new tube. The tube shield is selfcontained and telescopic with a bayonet locking feature to



maintain it in the raised position. With a slight twist, the upper half is disengaged and lowered so that the tube can be removed without difficulty and without prior removal of the shield. Detailed information can be received by writing to Cleveland Metal Specialties Company, 1783 E. 21st St., Cleveland 14, Ohio.

Printed Circuit Additions. A series of printed circuit connectors and additions to standard designs is announced by H. H. Buggie, Inc., Box 817, Toledo 1, Ohio. Printed circuit board receptacles are now one-piece body construction available in either type *GR* and *MFE* mineral filled phenolic, *MDG* diallyl phthalate or *CFG* general purpose phenolic. The board receptacle series have a new contact design to prevent board-to-contact damage. Contact material is beryllium copper, standard plating is gold over silver. Nylon polarizing keys permit quick interchangeable polarizations. Standard terminations are solder eye, taper tab (AMP), solder dip and wire wrap, for either single- or double-sided board circuits. Minimum creep is $\frac{3}{32}$ inch; working volts are 550 a-c, 770 d-c; and test voltage is 1,650 rms. The firm has added standard designs to its series of printed circuit terminal strips, terminal connector strips, and contact strips. For further information on printed circuit connectors, write to the company.

Low-Voltage Lighting Sets. These sets provide 200 to 400 watts of grounded illumination in a choice of 6, 12, or 32 volts, from conventional 110/120-volt a-c power sources. They are reported to be absolutely safe to use around metal structures, even in dripping wet conditions. Flyer No. *F45*, provides complete information. Write Department V-65, Joy Manufacturing Company, 1201 Macklind Ave., St. Louis 10, Mo., for a free copy.

(*Continued on page 28A*)

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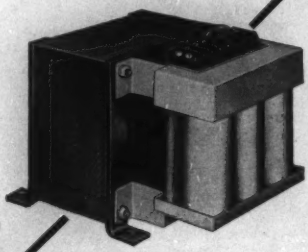
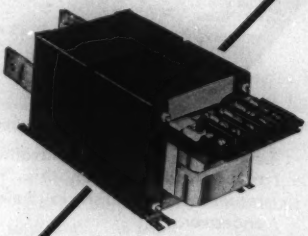


Input 190/208/230 volts ± 10% Output 54 to 77 volts, 10 amp.

or Filament Transformers



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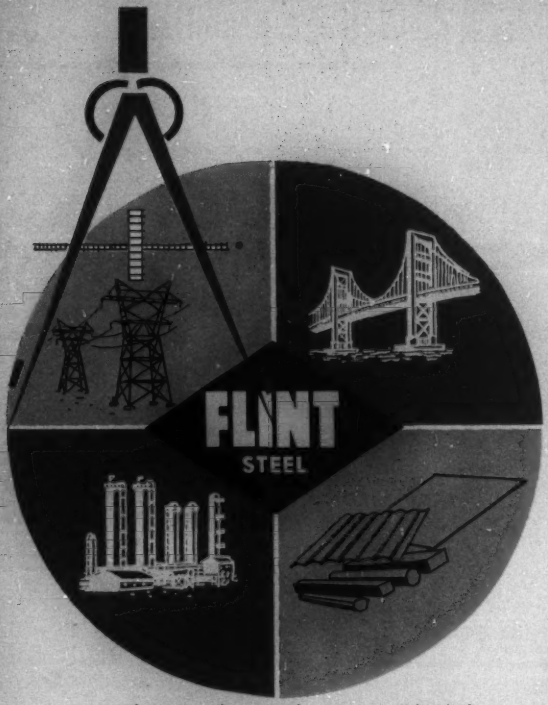

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New Products

(Continued from page 26A)

Listomatic Camera. The Listomatic camera that photographs tabulating cards in column listings on film is now being distributed and serviced by Recordak Corporation, Eastman Kodak Company announces. It has been renamed the Recordak Listomatic Camera and, principally, is a big time-saver in producing parts lists, telephone directories, catalogs, membership rosters, and credit rating books. For further information contact Recordak Corporation, Subsidiary of Eastman Kodak Company, 415 Madison Ave., New York 17, N.Y.

Plastic Diaphragm on Microphones. Restyled to a new "sculptured look," these transistorized dynamic mobile- and base-station microphones utilize specially developed plastic diaphragms for greater efficiency and utility. The new eye-appealing design eases handling and complements the design of "T-Power" radiophones and "Power Voice" speakers. The

two-tone diecast palm-size metal case, finished in perspiration-resistant paint, is able to withstand severe shock and vibration. For further information contact Motorola Inc., Communications and Industrial Electronics Division, 4501 W. Augusta Blvd., Chicago 51, Ill.

Jetec 30 Transistors Socket. This socket was designed for use with the new 3- and 4-pin JETEC *30* transistors. The socket body is molded from mica-filled phenolic per *MIL-M-14*, Type *MFE*. The beryllium copper contacts are wrap-around style, silver plated, and gold flashed for good contact and corrosion resistance. Contact numbers, molded into the rear of the socket, make identification very easy. Complete details and prices may be had by writing to Grayhill, Inc., 561 Hillgrove Ave., LaGrange, Ill.

(Continued on page 34A)

Now you can have a high degree of protection against the thermal and mechanical stresses that heavy fault currents often impose on switches or other circuit components.

FUSETRON Low-Peak Fuses have a current limiting element that cuts off fault current so fast that it cannot build up to a damaging peak.

These new FUSETRON Low-Peak Fuses are built on the same principle as FUSETRON dual-element Fuses. They have:

the same High Interrupting Capacity

the same Time-Lag to hold harmless current surges

PLUS Greater Current Limitation to restrict fault currents to a LOW PEAK

FUSETRON Low-Peak Fuses can be interchanged with FUSETRON dual-element Fuses.

Where their use is required in any part of the electrical system, they can be installed without upsetting proper coordination over the range of useful loads and normal faults.

Hence, their application requires no testing or complicated calculations.

They are designed for use to protect circuits and components that might be damaged by the thermal and mechanical stresses of peak fault currents if other protective devices are used.

If planning new installations, keep FUSETRON Low-Peak Fuses in mind for those locations where peak fault current must be held to a low value.

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New Products

(Continued from page 28A)

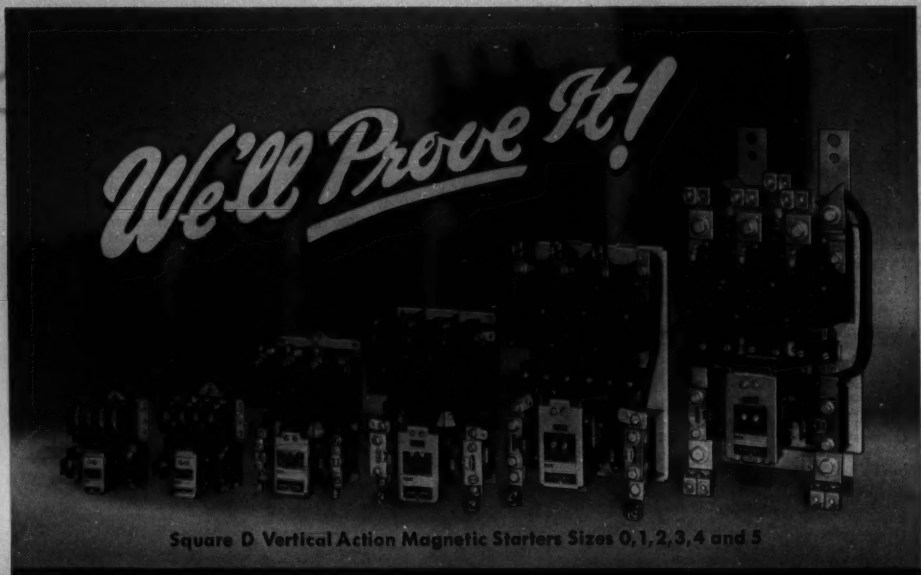
Manual By-Pass. A manual by-pass designed to meet needs for a safe, dependable, positive means of furnishing continuous service during meter removals and replacement has been announced. Designed to fit presently acceptable size troughs, the unit eliminates need for large, unattractive cabinets with extra covers, blocks, and seals. For further information contact John J. Doyle, Murray Manufacturing Corp., 1250 Atlantic Ave., Brooklyn 16, N.Y.

Teflon Spiral Cover. A new type of wire harnessing product known as Teflon Spiral Cover has been announced. Similar to the Spiral Wrap in many ways, Spiral Cover has the unique feature of overlapping itself 100%, thus forming a double cover over the wire, leaving no open points. Therefore, the insulating qualities are almost equal to solid jacketing. Made only in noninflammable Teflon in order to meet the growing demand for wire harnessing for high heat applications, Spiral Cover has an 0.040-inch wall and is available in six different diameters from ¼ inch to 1½ inch, and comes in various lengths. For a brochure on Teflon Spiral Cover, write to Illumitronic Engineering, 680 E. Taylor, Sunnyvale, Calif.

Consistently Uniform Bobbin Cores. These high quality magnetic bobbin cores produced in commercial quantities for digital data processing systems and small pulse transformers and high frequency magnetic amplifiers are now available from G-L Electronics, and are available in either of two materials: *4-79* molybdenum permalloy, a rectangular hysteresis loop material containing 4% molybdenum, 79% nickel, and 17% iron, characterized by minimum switching time for a given magnetomotive force (mmf) and medium saturation flux density; and Orthonik, a rectangular hysteresis loop material containing 50% nickel and 50% iron, characterized by high saturation flux density and medium switching time for a given drive mmf. A complete range of bobbin sizes are available, cores tested to rigid quality control specifications and guaranteed against defects caused by faulty materials or workmanship. For full information, write G-L Electronics, 2921 Admiral Wilson Blvd., Camden 5, N.J.

Two Programming Systems. Two interpretive floating-point coding systems for the Bendix *G-15* general purpose computer have just been announced by the manufacturer. Both systems use the same simplified codes, but differ in their degree of precision. The first system, INTERCOM *500*, handles numbers made up of five decimal digits and a two-digit exponent. The second, INTERCOM *1000*, handles numbers of 12 decimal digits and a two-digit exponent. For further information contact Bendix Computer, 5630 Arbor Vitae St., Los Angeles 45, Calif.

(Continued on page 36A)



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No change in trip characteristics because of mismatched parts supplied separately for field assembly, no distortion of heater in installation. Square D gives you melting alloy unit construction—factory-assembled and individually tested for bull's-eye accuracy. Also bi-metal and magnetic designs for automatic reset or adjustable trip applications.

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No starter is "maintenance-free." But Square D makes the job easy. Inspection is a breeze. You don't have to remove wiring for contact replacement or take the starter out of the enclosure to change coils.

5 *WIDE-RANGE* ADAPTABILITY!

No need for excessive inventories to avoid costly waiting for non-standard arrangements. Square D provides "off-the-shelf" kits for changing contacts and coils, adding pushbuttons, selector switches, and up to 4 double-throw auxiliary circuits.

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84 Contributing, Consulting Editors 6x9 1740 pp. 991 ills. $20

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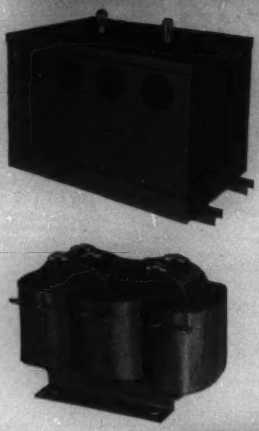


Hevi-Duty Saturable Reactors are used for the manual or automatic control of power to a load. Loads such as electrically heated equipment, motor starting circuits, test boards and many other industrial power uses are ideal applications.

By changing the magnetic characteristics of the reactor core, the impedance can be varied by means of a direct current control winding. This feature provides:

1. **Stepless control in the AC power circuit.**
2. **A wide range of control with smooth and even adjustment over the entire range.**
3. **Small voltage drop in reactor at full saturation, permits 90% of the line voltage to be applied to the load.**

The Hevi-Duty Reactor is a compact unit requiring a minimum of mounting space and is sturdily constructed to give years of dependable service. Each reactor is rigidly tested to meet or exceed NEMA Standards. If you have a Saturable Reactor application, Hevi-Duty engineers will be glad to design or assist you in selecting the proper size for your particular application. For additional information on Hevi-Duty Saturable Reactors, write for Bulletin 500 today.

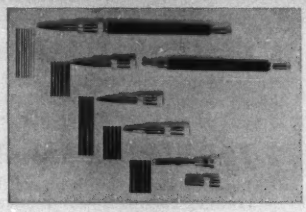
HEVI-DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES HEVI-DUTY ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS
MILWAUKEE 1, WISCONSIN

New Products

(Continued from page 34A)

Overload Relay. An overload relay, called the Type *SD*, has been introduced. Among the many outstanding design features of the new line of Rowan Overload Relays, not to be found in ordinary types of overloads, is full 3- or 2-phase protection without using additional space and complete adjustabilty to permit final and accurate field adjustments to exact motor loads. Full information on the Type *SD* overload relays may be obtained by writing directly to the Rowan Controller Company, 2315 Homewood Ave. Baltimore 18, Md.

Versatile Drafting Pen. A capillary-controlled drafting pen which permits use of ordinary ink on any drawing surface is now on the market. The Riefler Grafika, a precision-made instrument, will draw a line in excess of 1,000 feet without refilling, in contrast to lines a few inches in length possible with ordinary drafting pens. Rubber-base, fountain pen, colored, or India inks, in addition to water colors, can be used with the Grafika pen on any medium, including paper, acetate, cloth, Mylar, or glass. In addition, lettering attachments permit use of the Grafika with any type of lettering guide or template or for a variety of types of freehand work. Five interchangeable ruling nibs allow a continuous range of line widths from hair line to $\frac{3}{16}$ inch. Each nib is infinitely adjustable within its range. In addition to eliminating the danger of blotting, the Grafika will join lines without any discernible thickening at connecting points. Even when the point is lifted, heavy lines terminate perfectly in pure right angle ends, an effect which must ordinarily be minutely hand drawn by the draftsman. For further information, write to Ozalid Division, General Aniline & Film Corporation, 2 Corliss Lane, Johnson City, N.Y.



Three-Position Air Circuit Breakers. Type *DB*, 600-volt, 15- to 4,000-amperes, metal-enclosed switchgear with three-position breaker design is now available from the Westinghouse Electric Corporation. The interrupting rating of the units are from 15,000 to 100,000 amperes. For further information, write Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh 30, Pa.

(Continued on page 38A)

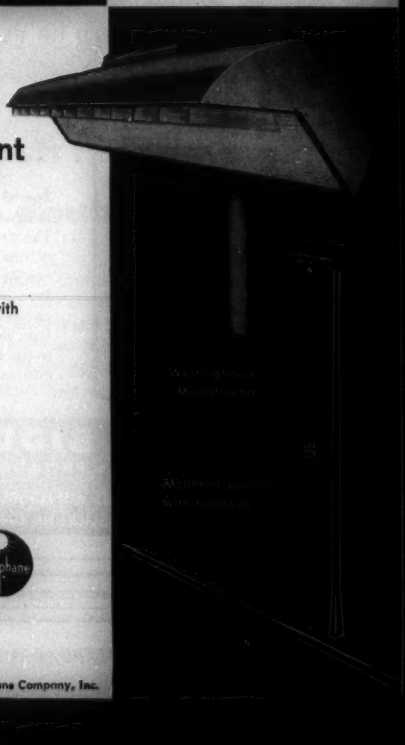
Holophane

Prismalume®

No. 4800 Prismatic
Acrylic Plastic

HOLOPHANE LINEAR REFRACTOR

for Westinghouse Type HUS-Fluorescent Street Luminaires



A new basic concept in street lighting... using established principles of prismatic light control to provide highly effective fluorescent illumination with very low glare. By test, the veiling glare of these new luminaires is only a fraction of that resulting from conventional fluorescent types... The advancement in lighting efficiency is noteworthy. Holophane Linear Refractors can increase the amount of useful light directed to pavements and sidewalks by over 50%. *Write for engineering data.*

HOLOPHANE COMPANY, INC.

Lighting Authorities Since 1898 • STREET LIGHTING DEPARTMENT • NEWARK, OHIO

THE HOLOPHANE CO., LTD., 418 KIPLING AVE. SO., TORONTO 14, ONTARIO

Copyright 1958, Holophane Company, Inc.

New

MEGGER® LOW RESISTANCE OHMMETER

- **Completely Self-Contained**
- **Convenient, One-Man Operation**
- **Battery or Rectifier-Operated Models**

RANGES
0 to 1,000 microhms
0 to 10,000 microhms
0 to 100,000 microhms
0 to 1 ohm

The new Megger Low Resistance Ohmmeter is a direct-reading instrument of sturdy, compact design. Has wide application in electrical maintenance for resistance measurements of electrical conductors, joints, contacts and windings of the low resistance type in oil circuit breaker assemblies, rotating electrical equipment, transformer and coils. This instrument is also most useful for controlling manufacturing and assembly processes which include identification and classification, in terms of resistance, of metal and metal alloy components.

IDEAL FOR FIELD OR BENCH USE

Two models of the Megger Low Resistance Ohmmeter are available. One has a battery power supply for field use. The other has a rectifier which can be plugged into any ordinary lighting circuit outlet for bench use. Each is equipped with automatic quick-acting circuit-breaker.

FEATURES

1. Measures accurately to 10 microhms
2. Open, easy-to-read, 3¼" scale
3. 4 ranges: In addition to the x1 position on the selector switch it multiplies scale x10, x100 and x1000
4. Small size—13" x 6" x 7"
5. Light weight—only 10 pounds
6. Sturdy carrying case keeps instrument, leads and prods in one place, ready for use.

NEW CLAMP DESIGN ON TEST LEADS

Special clamp type test leads 18 feet long are available on special order. The extra length facilitates tests in elevated or remote locations without moving the instrument close by. Especially important in testing large circuit breakers. Clamps are of duplex type, each makes current and potential connection when applied. This permits one man to make tests.

8 802

JAMES G. BIDDLE CO.
1316 ARCH STREET • PHILADELPHIA 7, PA.
ELECTRICAL TESTING INSTRUMENTS • SPEED MEASURING INSTRUMENTS
LABORATORY & SCIENTIFIC EQUIPMENT

James G. Biddle Co.
1316 Arch St., Phila. 7, Pa.
Please send me
BULLETIN 24-46-EE

Name _____
Company _____
Address _____
City _____ Zone _____ State _____

New Products

(Continued from page 36A)

Angular Generator. A floor model angular acceleration and rate generator for running tests on accelerometers and rate gyros has been developed. Frequency and acceleration characteristics are infinitely adjustable within the range of the unit by sliding weights inward or outward on a suspension arm, by using heavier or lighter weights, or by varying the winding of the torsion bar that powers the generator. To achieve widely different ranges, the torsion bar itself may be changed. As a result of these adjustability features, a range from 0.5 to 200 radians per second² is obtained. Motion of the accelerometer or rate gyro on test is transmitted to a built-in 358° potentiometer of 9,000 ohms resistance. For further technical information, write to Humphrey Inc., 2805 Canon St., San Diego 6, Calif.

Explosionproof Variable Autoformers. Three explosionproof variable autoformers are now available for controlling power line voltage in hazardous areas. Designed especially for panel mounting, the units feature lightweight cast-aluminum housings and compact construction. Model *6240* has a power input of 120 watts, 60 cycles per second and output of 0 to 140 volts, 7.5 amperes, 1.0 kva maximum. The weight is 29 pounds. It is normally supplied with a Type *116* Powerstat. Medium size Model *7001* has an output of 0 to 135 volts, 3 amperes, weighs 19 pounds, has a Type *20* Powerstat. Small size Model *7009* weighs only 8½ pounds and has an output of 0 to 132 volts, 1/25 amps with a Type *10* Powerstat. Separate technical bulletins are available on all models. Send requests directly to I-L-S Instrument Corp., 4540 W. 160th St., Cleveland 11, Ohio.

Three Axis Flight Simulator. The Model *1806* Three Axis Flight Simulator has been developed by Aircraft Armaments, Inc. and designed for a test unit approximately 3 feet long, weighing 300 pounds. A lateral clearance of 5 feet was allowed about the test unit for external equipment. The flight simulator is capable of unlimited motion about any axis. A maximum load inertia of 550 slug-ft² can be accelerated up to 5 radians per second² and a maximum velocity of 30 rpm may be attained with a velocity error of 1%. The simulator has vertical and horizontal clearance requirements of approximately 11 feet. For further information contact Aircraft Armaments, Inc., Cockeysville, Md.

Straight-Frame Push-Button Switch. A line of straight-frame push-button switches has been announced as available in 3 ampere standard rating, single-make single-break single-pole double throw; two-make two-break, double-pole double throw; and three-pole double throw types. Ratings may be increased up to 10 amperes at 110 volts a-c noninductive load through use of special contacts and suitable current carrying materials. For further information contact Richards Electrocraft, Inc., 4432 N. Kedzie Ave., Chicago, Ill.

Your NATIONAL brush man showed this electroplater how to double brush life!

CLIFF BROWER

Rapid brush wear was limiting generator performance at this busy electroplating plant, says "National" Carbon Brush Man, Cliff Brower. No other industrial brush solved the problem until Cliff suggested a newly developed "National" brush grade.

That was five years ago. Since then not one commutator has been stoned or turned. Brush wear has been even, with no selective action or overheating—even under 20% overloads. This "National" BGX brush grade actually doubled brush life.

Cliff Brower and his fellow "National" Carbon Brush Men have been solving industrial brush problems for years. Their experience and training—backed by "National" *long term brush development*—make them the best consultants on any industrial brush problem.

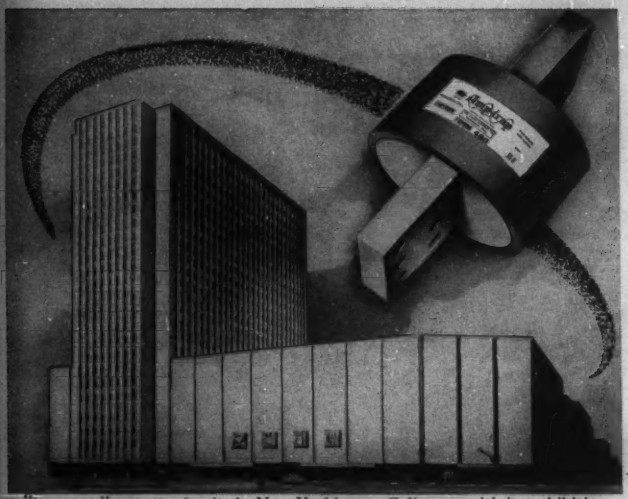
Call your "National" Brush Man today. Or write National Carbon Company, Division of Union Carbide Corporation, 30 E. 42nd St., New York 17, N. Y.

The terms "National", "N" and Shield Device, and "Union Carbide" are registered trade-marks of Union Carbide Corporation

UNION CARBIDE

NATIONAL CARBON COMPANY • Division of Union Carbide Corporation • 30 East 42nd Street, New York 17, N.Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. *In Canada:* Union Carbide Canada Limited, Toronto.



"Amp-trap" protects circuits in New York's new Coliseum, with its exhibition halls and amphitheatre, against the danger of heavy short- circuit or fault currents, regardless of varying load requirements.

SHAWMUT'S FORM 480 Amp-trap®

FOR APPLICATION ON ENTRANCE SWITCHES, BUSWAYS, FEEDER SERVICES AND CIRCUIT BREAKERS
ON AC CIRCUITS UP TO 600 VOLTS
ON DC CIRCUITS UP TO 250 VOLTS

- Positive Protection against Super currents as high as 500,000 peak amperes available.
- Built in Ampere Ratings of 600, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000 and 6000.
- Sharp Current Limitation Characteristics for Backup Protection of Air Circuit Breakers, Switches, etc.
- Easily Adaptable into Busses, Bus Ducts or Switches.
- Economical in First Cost and Replacement.
- Very Low Watt Loss — Cool Operation.

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480-Amp-trap® — "Awake At The Switch"

THE CHASE-SHAWMUT CO.
374 MERRIMAC STREET • NEWBURYPORT, MASSACHUSETTS
Subsidiary of I-T-E CIRCUIT BREAKER CO., Philadelphia, Pennsylvania

Amp-trap Trion C-O-T Trionet FUSE WIRE

TRADE LITERATURE

Specialized Products Booklet. "Sky High to Ocean Blue," a 12-page 2-color booklet, discusses in words and illustrations the specialized drives and motors engineered and built to the toughest industrial and Government specifications by Reliance Electric and Engineering Company. Copies of the booklet, designated Bulletin *A-2400*, may be had free by writing to Reliance Electric and Engineering Company, 24701 Euclid Ave., Cleveland 17, Ohio.

Powdered Metal Process Booklet. This colorful, 16-page booklet in handy pocket size shows "How To Cut Precision Parts Costs with the Remet Powdered Metal Process." The booklet tells what the powdered metal process is and does, states advantages and limitations, illustrates good and bad parts-design factors, and charts material specifications. It is free on request from Reese Metal Products Corp., 535 Howard Ave., Lancaster, Pa.

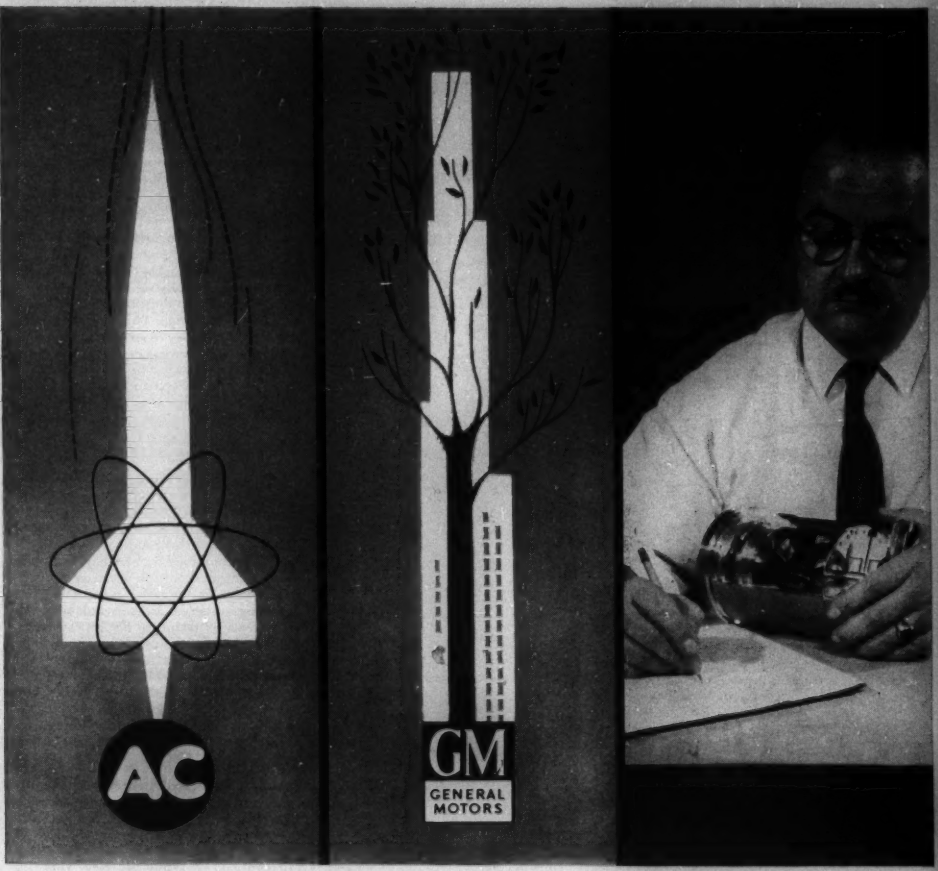
AMA Catalog. The 1957-58 catalog of all current American Management Association (AMA) publications, periodicals, and films is being made available on a complimentary basis to any interested executive writing on his business stationery. Readers may obtain copies by contacting Publication Sales, American Management Association, 1515 Broadway, New York 36, N. Y.

Electro-Magnetic Relay Symposium. A 136-page publication, "Fifth Symposium on Electro-Magnetic Relays," has been made available by Potter & Brumfield, Inc., subsidiary of American Machine & Foundry Company, Princeton, Ind. In this book, the papers presented at the National Conference on Electro-Magnetic Relays, Oklahoma State University, Stillwater, Okla., are reprinted.

Peracetic Acid and Derivatives Booklet. A 48-page booklet on "Peracetic Acid and Derivatives" has just been issued which includes a treatise on peracetic acid, reactions of epoxides, and an extensive bibliography supporting these sections. It also lists properties and possible uses of 12 epoxides now available in research samples. For copies of this booklet, "Peracetic Acid and Derivatives: *F-40, 108*," write Union Carbide Chemicals Company, 30 E. 42nd St., New York 17, N. Y.

Epoxy Dermatitis Prevention. A 12-page booklet cites hazards of epoxy dermatitis and lists 36 specific and practical rules for prevention. Recommendations are grouped under five headings: education of workers and supervisors, company housekeeping procedures, ventilation, personal cleanliness of workers, and use of protective creams and clothing. The booklet is available free in quantities for distribution to supervisors or to workers on epoxy operations as part of company safety education program. Write to Milburn Company, 3246 E. Woodbridge, Detroit 7, Mich.

(Continued on page 46A)



THIS IS A CHALLENGE . . . AC, today, is counted among the leaders in the electronics industry, working full speed to meet vital commitments for our armed forces . . . and for industry, too.

THIS IS A SOUND FUTURE . . . AC, like all General Motors, is soundly based and increasing in size each year. Here is security and an opportunity to grow with a growing organization.

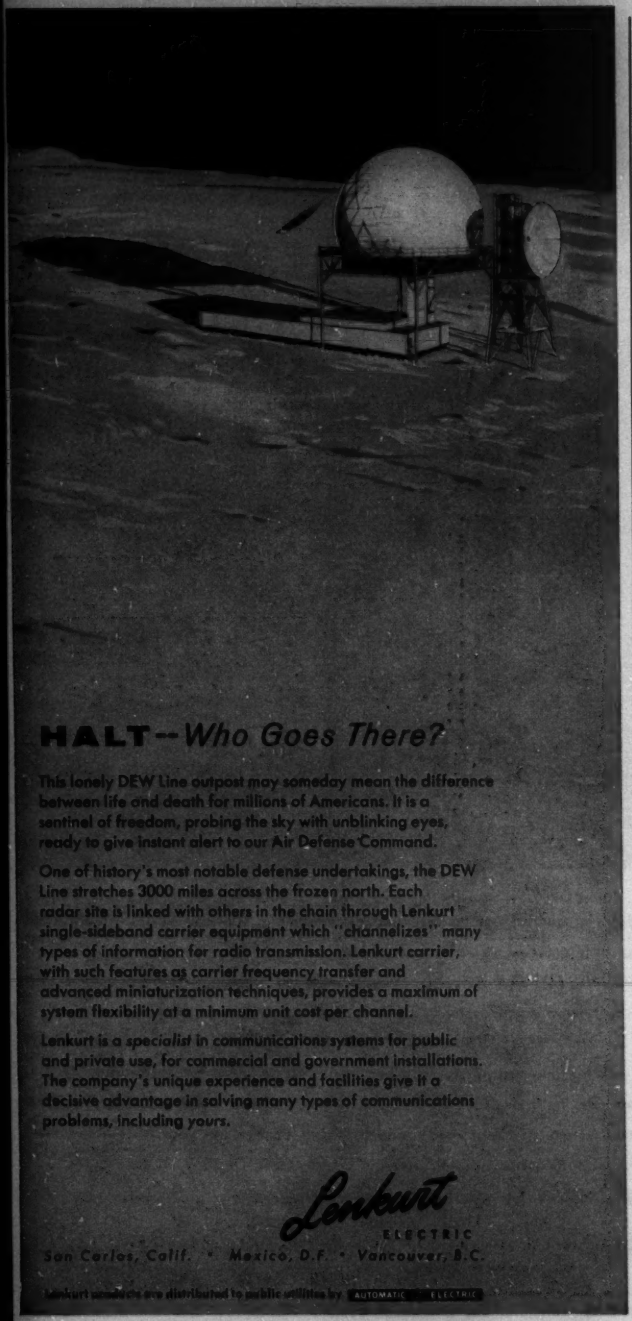
THIS MAY BE FOR YOU . . . Read over the product list below. There are opportunities today with the engineering groups working on each one of these items.

AC is now looking for experienced men who hold degrees in mechanical or electrical engineering. If you have from 3 to 10 years' technical experience in one of these fields, and the idea of working with AC's Milwaukee group appeals to you, write Mr. Cecil Sundeen, Supervisor of Technical Employment, Dept. B, in care of AC . . . the Electronics Division of General Motors, 1925 E. Kenilworth, Milwaukee 1, Wisconsin.

AC . . . THE ELECTRONICS DIVISION OF GENERAL MOTORS

Milwaukee 1, Wisconsin

Afterburner Fuel Controls • Bombing Navigational Computers • Emergency Fuel Controls • Gun-Bomb-Rocket Sights • Gyro-Accelerometers • Gyroscopes Inertial Guidance Systems • Manifold Air Pressure Regulators • Speed Sensitive Switches • Speed Sensors • Three-Way Selector Valves • Torquemotors


HALT--Who Goes There?
This lonely DEW Line outpost may someday mean the difference between life and death for millions of Americans. It is a sentinel of freedom, probing the sky with unblinking eyes, ready to give instant alert to our Air Defense Command.
One of history's most notable defense undertakings, the DEW Line stretches 3000 miles across the frozen north. Each radar site is linked with others in the chain through Lenkurt single-sideband carrier equipment which "channelizes" many types of information for radio transmission. Lenkurt carrier, with such features as carrier frequency transfer and advanced miniaturization techniques, provides a maximum of system flexibility at a minimum unit cost per channel.
Lenkurt is a specialist in communications systems for public and private use, for commercial and government installations. The company's unique experience and facilities give it a decisive advantage in solving many types of communications problems, including yours.
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San Carlos, Calif. • Mexico, D.F. • Vancouver, B.C.
Lenkurt products are distributed to public utilities by AUTOMATIC ELECTRIC

Trade Literature

(Continued from page 44A)

Millisecond Operations Recorder Described. Catalog *30A1400* describes the Millisecond Operations Recorder (MOR) for continuous automatic logging of power station operations at cost one third less than previous methods. For a free copy, write to Fischer & Porter Company, 488 Jacksonville Rd., Hatboro, Pa.

Anti-Oxidant Compound Bulletin. A two-page bulletin, *HV10-305*, that not only describes a new anti-oxidant compound for making trouble-free electrical joints, but also gives application and technical data has been offered. This new compound chemically removes oxide films from aluminum or copper without harming the base metal. Joints made with it have an extremely low resistance that equals silver-plated connections. Contact the Hi-Voltage Equipment Company, a Division of Joslyn Mfg. & Supply Co., 4000 E. 116th St., Cleveland 5, Ohio.

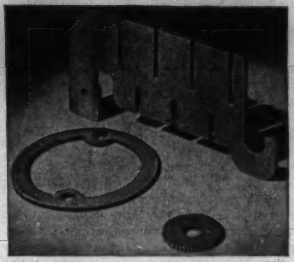
Automation Controls Catalog. A catalog titled "Automation Controls" has just been released for general distribution, it was announced by General Controls Co., manufacturer of automatic controls. This catalog groups together, for the first time under one cover, a wide selection of automatic controls most commonly used in designing automatic systems. Included are such items as counting devices, switches, electric valves, actuators, relays, limit controls, time switches, and a host of accessory equipment which the engineer can use as building blocks in selecting the components for tailoring an automated system. A free copy may be obtained by writing General Controls Co., 801 Allen Ave., Glendale 1, Calif.

Relay Catalog. Recently issued is a 32-page catalog showing relays, steppers, solenoids, rectifiers, and other electronic components. Copies of the catalog may be obtained by writing to Universal Relay Corporation, 42 White St., New York 13, N. Y.

Printed Circuits Etching Process. A process for etching printed circuits with a solution of ammonium persulfate instead of ferric chloride is described in Bulletin *90*, recently published. Bulletin *90* may be obtained free upon request from Becco Chemical Division, Food Machinery and Chemical Corporation, Station B, Buffalo 7, N. Y.

Thermoswitch Temperature Controls Folder. "Got a Temperature Control Problem?" is the title of a new folder which describes how a "Thermoswitch" unit can help equipment run at faster speeds, require less maintenance, and have longer life and reduced assembly costs. Also included are complete construction details of the control and six basic design configurations. Copies of this folder, Bulletin *MC-157*, may be obtained from Fenwal Incorporated, Pleasant St., Ashland, Mass.

(Continued on page 48A)

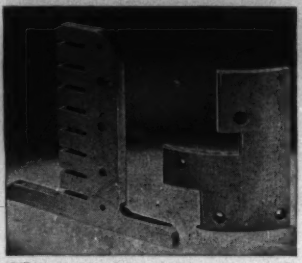


LEFT: Sheet stock; shear strips and punch. **TOP:** Sheet stock; shear strips, punch blank, gang-saw notches. **BOTTOM:** Sheet stock; shear strips, punch blank, mill notches.

TOP LEFT: Sheet stock; shear strips, punch, form. **CENTER:** Sheet stock; shear to size, drill, form. **BOTTOM RIGHT:** Sheet stock; shear strips, punch pieces, form twice in mold, rubber-stamp twice.

LOWER LEFT: Hexagonal rod; smooth-saw, automatic screw machine, turn shoulder thread, chamfer, and cut off. The other samples are automatic-screw-machine parts made from Diamond Fibre by C-D-F.

LEFT: Sheet stock; sand, smooth-saw to size, smooth-saw bevel, smooth-saw corner cut-out, drill. **CENTER:** Sheet stock; band-saw, turn OD, bore ID, smooth-saw side, drill five blind holes with jig. **RIGHT:** Sheet stock; sand, band-saw, rough-bore ID, hob teeth, finish-bore ID, machine keyway.



LEFT: Sheet stock; sand, smooth-saw, drill, smooth-saw to shape, radius three corners, gang-saw notches. **RIGHT:** Sheet stock; band-saw rough blanks; form; smooth-saw width, length, and shape; radius edges; drill with jig; countersink.

LOWER LEFT: Tube stock; automatic screw machine, turn shoulders, chamfer and thread end, thread other end. **UPPER LEFT:** Tube (two diameters); smooth-saw, tap, screw-machine larger piece; screw-machine, thread, knurl, chamfer, cut off small piece. **UPPER RIGHT:** Tube; smooth-saw to length, punch twice, countersink. **LOWER RIGHT:** Tube; screw-machine, chamfer, cut off, punch.

C-D-F fabricates and forms DIAMOND VULCANIZED FIBRE

FAST . . . AT LOW COST . . . DEPENDABLY

Vulcanized Fibre is a wonderful material if you know where to use it and how to buy it. We suggest on many jobs that it's best to do the fabrication and forming in C-D-F's shops. Why? Because C-D-F knows how. Since 1895 the company has put fibre to work in everything from buggy axle bushings to metal clad radio parts. The handling of thousands of set-ups for high speed, low cost production runs gives C-D-F an "experience bank" to draw from. Shop supervisors have a wealth of short cuts, little tricks that result in lower prices for you. They know the material and its peculiarities.

TOUGH, RESILIENT, STRONG

How long has it been since you examined the unique properties and wide range of C-D-F fibre grades? Vulcanized Fibre is arc resistant, mechanically strong, non-corroding, half the weight of aluminum. Repeated moistening and drying in forming insignificantly alters the nature, structure or quality of the fibre.

Since C-D-F has their own paper mill, uniform, quality control is made possible. Special grades are more easily developed. A good example is C-D-F Abrasive Fibre, a medium density fibre with excellent resin and grit adhesion, now widely used for abrasive discs.

A BIG, RELIABLE SOURCE

C-D-F does business with the largest tonnage users of sheet, rod and tube fibre in the world. This means good deliveries, good prices, reliable products for every new customer. You deal with a materials engineer, a C-D-F man who knows how to give you the most value in Diamond Vulcanized Fibre. If you want to improve design, simplify purchasing, speed production, use Diamond Fibre and the facilities of C-D-F. Write for catalog, free test samples, or send us your print for quotation.

CDF

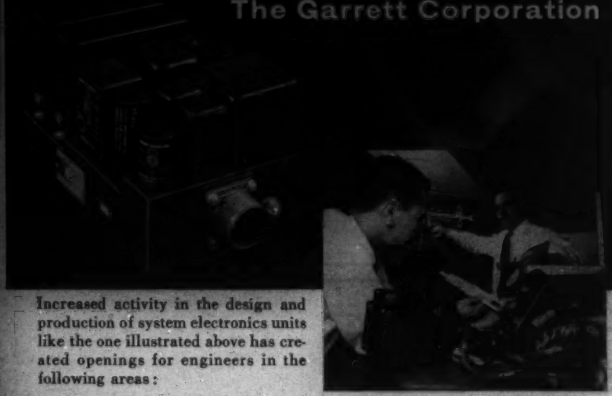
CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Budd COMPANY, INC.

NEWARK 86, DELAWARE

ENGINEERS...

cross new frontiers
in system electronics at
The Garrett Corporation



Increased activity in the design and production of system electronics units like the one illustrated above has created openings for engineers in the following areas:

- **ELECTRONIC AND AIR DATA SYSTEMS** Required are men of project engineering capabilities to participate in the design and development of complete electronic control and air data systems for use in current and future high performance aircraft. Also required are development and design engineers with specialized experience in servo-mechanisms, circuit and analog computer design utilizing vacuum tubes, transistors, and magnetic amplifiers.
- **SERVO-MECHANISMS AND ELECTRO-MAGNETICS** Work includes the design and development of magnetic amplifier control devices and integration of components into finished systems. Servo-system analysis and performance prediction would be helpful. Complete working knowledge of electromagnetic theory and familiarity with materials and methods employed in the design of magnetic amplifiers is required.
- **FLIGHT INSTRUMENTS AND TRANSDUCER DEVELOPMENT** Requires engineers capable of analyzing performance during preliminary design and able to prepare proposals and reports. Experience with sensitive aircraft instruments, servos, gyros, auto pilots and flight controls is desirable.
- **FLIGHT INSTRUMENTS DESIGN** Requires engineers skilled with the drafting and design of light mechanisms for production in which low friction, freedom from vibration effects and compensation of thermo expansion are important. These mechanisms frequently involve instruments, bearings, gears, bellows, diaphragms, cams, potentiometers, linkages and small electric motors.
- **HIGH FREQUENCY MOTORS, GENERATORS, CONTROLS** Requires electrical design engineers with BSEE or equivalent interested in high frequency motors, generators and associated controls. Experience in the field of aircraft motors and generators, servo-motors or high speed, high frequency machine tool motors helpful. The field of power supply and utilization equipment on modern aircraft and missiles provides excellent opportunities.

Send resume of education and experience today to:
Mr. G. D. Bradley

THE GARRETT CORPORATION
9851 S. SEPULVEDA BLVD., LOS ANGELES 45, CALIFORNIA

DIVISIONS:
AIRESEARCH MANUFACTURING, LOS ANGELES • AIRESEARCH MANUFACTURING, PHOENIX
AIRESEARCH INDUSTRIAL • REX • AERO ENGINEERING
AIRSUPPLY • AIR CRUISERS • AIRESEARCH AVIATION SERVICE

Trade Literature

(Continued from page 46A)

Vacuum Calculator. Vacuum engineers will find extremely useful for a number of computing chores the new Stokes vacuum calculator, which has just been revised and brought up-to-date. A handy-sized slide-rule for quickly determining the pumping capacity, the Calculator also displays the vapor pressure of water at various temperatures, the capacities of round tanks of different diameters in terms of both cubic feet per foot and gallons per foot, the boiling points of 11 common solvents at various pressures, etc. It may be obtained free on request from the Vacuum Equipment Division, F. J. Stokes Corporation, 5500 Tabor Rd., Philadelphia 20, Pa.

Humidity-Temperature Instrumentation Catalog. An information-packed 6-page catalog describing relative humidity and temperature instrumentation is now available in which design and construction details are provided for a complete line of humidity indicators, recorders, and controllers. Accessory photographs and descriptions are included. The catalog is available free upon request from Serdex, Inc., 12 Bowdoin Sq., Boston 14, Mass.

Controls Bulletin. Simple all-purpose electrical controls, known as Versatrols and suitable for use with virtually any detectable variable, are described in a 12-page Bulletin *106*, issued by Assembly Products, Inc., Wilson Mills Rd., Chesterland 53, Ohio.

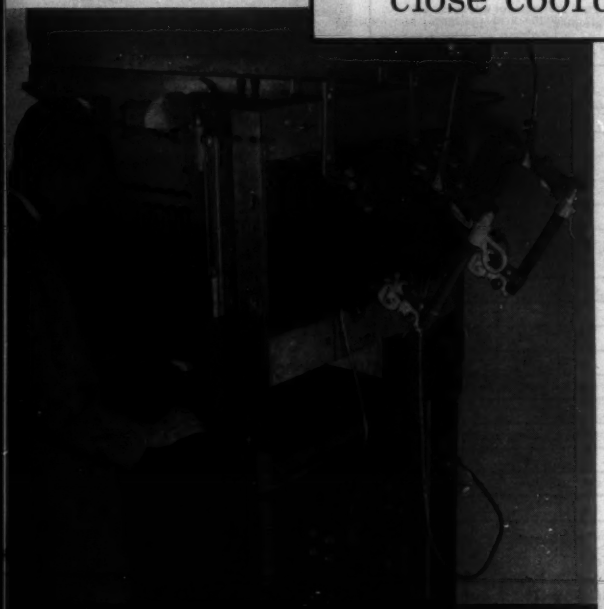
Pipe Insulation Fact Finder. A handy slide fact finder for pipe insulation is now available. The fact finder permits the user to select quickly and easily the most economical thickness of pipe insulation. It gives the insulation surface temperature and the Btu loss per lineal foot per hour for various insulation thicknesses on pipe ranging from 1 inch to 24 inches in diameter where pipe temperature is 300F to 1,200F. Easy to use and carry, the Unibestos fact finder is plastic coated. Available without charge by writing on business letterhead to Union Asbestos & Rubber Company, 1111 W. Perry St., Bloomington, Ill.

Aluminum Substation Brochure. The first comprehensive study of electrical substation structures constructed of aluminum has been published in booklet form by the Industry Development Department, Kaiser Aluminum & Chemical Sales, Inc., Department *NR-3*, 919 N. Michigan Ave., Chicago 11, Ill. The 48-page brochure, "Aluminum Substation Structures," has been prepared as a basic guide for engineers, designers, fabricators, and erectors of substations and tells where and why the application of aluminum results in greater savings, better performance, and longer life.

(Continued on page 58A)

It takes KEARNEY QUALITY in Fuse Links

to give you positive protection . . . close coordination



Controlled manufacture and rigorous testing provide maximum service continuity

Quality control in KEARNEY Fuse Links starts with design . . . and continues through careful selection of materials, precision parts manufacture, expert assembly and strictest inspection and testing. The end result is dependable protection . . . uniformity that guarantees all Fuse Links of the same rating will perform exactly alike.

ALL KEARNEY Fuse Links feature low temperature operation. Pure tin elements or low melting point solder, selected for proper strength and melting temperature for each current rating, keep temperatures inside the cutout tube well below charring point. This provides accurate, positive arc clearance even after long periods of overload.

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(Continued from page 48A)

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